JPRS-USP-87-001

19 FEBRUARY 1987

USSR Report

SPACE

FBIS FOREIGN BROADCAST INFORMATION SERVICE

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS-USP-87-001

19 FEBRUARY 1987

USSR REPORT

SPACE

CONTENTS

SPACE APPLICATIONS

TASS REPORT ON FLIGHTS OF UNMANNED 'MIR' AND 'SALYUT-7' STATIONS

Moscow VECHERNYAYA MOSKVA in Russian 20 Dec 86 p 1

[TASS Report]

[Text] Flight Control Center, 19 December. The orbiting station "Mir" has been functioning in near-Earth space for 10 months. It has been flying in the automatic mode since the completion of Leonid Kizim's and Vladimir Solov'yev's expedition. According to telemetry data, the "Mir" station's onboard systems are operating normally. Its orbit parameters are: maximum distance from the surface of Earth--349 kilometers; minimum distance from the surface of Earth--321 kilometers; period of revolution--91.1 minutes; inclination--51.6 degrees.

The flight of the orbiting complex "Salyut-7"--"Cosmos-1686" is continuing. Four months ago, this complex was moved into a nearly circular orbit, whose altitude is now about 480 kilometers. Service-life tests of the "Salyut-7" station are being conducted in line with a designated program.

The control center is processing incoming information.

FTD/SNAP
/8309
CSO: 1866/45

MANNED MISSION HIGHLIGHTS

CREWS NAMED FOR SOVIET-SYRIAN MANNED MISSION

Kiev PRAVDA UKRAINY in Russian 19 Dec 86 p 2

[Text] On December 17, Soviet and Syrian scientists and specialists held a meeting in Moscow on questions of preparing for a joint space mission in 1987. International crews for the Soviet-Syrian mission were named.

Aleksandr Stepanovich Viktorenko is the commander of the first crew. Its other members are USSR pilot-cosmonaut Aleksandr Pavlovich Aleksandrov, the flight engineer, and cosmonaut-researcher Muhammed Ahmed Faris, a citizen of the Syrian Arab Republic.

The members of the second crew are Anatoliy Yakovlevich Solovyev, the commander; USSR pilot-cosmonaut Vikto Petrovich Savinykh, the flight engineer; and cosmonaut-researcher Munir Habib Habib, a citizen of the Syrian Arab Republic.

A decision was made regarding the further training of the Syrian cosmonauts for the joint space flight as members of the designated crews.

FTD/SNAP
/8309
CSO: 1866/45

COSMONAUT CREWS FOR USSR-SYRIA FLIGHT PRESENTED

LD192215 Moscow Television Service in Russian 2043 GMT 18 Dec 86

[Special report on USSR Foreign Ministry press conference held 18 December devoted to USSR-Syria space launch; presented by correspondent A. Galkin after conclusion of "Vremya" newscast]

[Text] [Galkin] Two Syrian pilots, candidate cosmonauts, have completed a course of theoretical studies in Zvezdnyy Gorodok. From the new year onward they will begin to prepare for the expedition into orbit. They were presented at the press conference by Air Force Major General Leonov, deputy head of the Cosmonaut Training center. [Video: Medium shot of those holding the press conference seated on platform behind long desk, shots of journalists taking notes]

[Leonov] The research cosmonauts of the Syrian Arab Republic Lieutenant-Colonel Muhammad Faris and Lieutenant-Colonel Munir Habib, arrived at the Cosmonaut Training Center in October 1985. During that same month they started the general space training program. General space training included the study of fundamental sciences connected with the study of disciplines such as flight dynamics, control systems, the fundamentals of space navigation, practical work on simulators, medico-biological training, physical training and the study of the Russian language. A total of 1,400 hours was spent. In the period from September until December the research cosmonauts studied spacecraft including the specific systems of the "Soyuz-T" spacecraft and the "Mir" orbiting station on which they will have to fly, and studied the systems with which they will have to work.

All in all, to date they have arrived at a level where a crew can be formed and the direct preparation for the space flight can be started. The decision regarding the makeup of the crews was taken yesterday.

The main crew is made up as follows: Commander, Lt-Col Aleksandr Stepanovich Viktorenko; flight engineer, USSR pilot cosmonaut, Hero of the Soviet Union Aleksandr Pavlovich Aleksandrov; and research cosmonaut, Lt-Col Muhammad Ahmad Faris.

The backup crew is made up as follows: crew commander, Lt-Col Anatoliy Yakovlevich Solovyev; flight engineer, USSR Pilot cosmonaut, twice Hero of the Soviet Union Viktor Petrovich Savinykh; and research cosmonaut, Lt-Col Munir Habib Habib.

The commander of the main crew is Lieutenant-Colonel Aleksandr Stepanovich Viktorenko. He was born in 1947. In 1969 he graduated from the Orenburg Higher Air Force College. He is a first class military pilot and a third class test pilot. He has undergone a very long training as a test cosmonaut and was repeatedly the commander of backup crews under the programs of the "Salyut" and "Mir" orbiting stations.

Flight engineer Aleksandr Pavlovich Aleksandrov, Hero of the Soviet Union, was born in 1943. In 1983 he carried out a 150-day space flight aboard the Salyut-7--Soyuz-T orbiting complex. Together with Comrade Viktorenko, his commander, Aleksandrov acted as a backup crew for the Kizim-Solovyev crew.

On the whole, they are experienced comrades.

The research cosmonaut of the main crew, Lt-Col Muhammad Ahmad Faris, was born in 1951. He is a military pilot and instructor. He arrived at the Cosmonaut Training Center in 1985 and during this period he showed a very high level of knowledge of what he had been taught. [Video shows Leonov, other cosmonauts, and audience]

The commander of the second crew, Lt-Col Solovyev, was born in 1948. In 1972 he graduated from the Chernigov Higher Air Force College. He is a first class military pilot and a second class test pilot. He has been at the Cosmonaut Training Center since 1976.

Flight engineer of the second crew, Viktor Petrovich Savinykh, was born in 1940. He has carried out two space flights.

Research cosmonaut of the second crew, Lt-Col Munir Habib Habib, was born in 1953. He is a military pilot instructor.

That's some brief information about the crews.

[Galkin] Abdallah al-Zurf, general of a Syrian Air Force division, has stated: We have brought from our country the warmest wishes to the Soviet people and the hope that the Soviet-Syrian crew will successfully fulfill its mission which we consider to be a bright material expression of the friendship and cooperation which links our countries. He also stressed that usually the candidate of the main crew is designated by the country from which the cosmonauts come, but we value equally highly both Muhammad Faris and Munir Habib; therefore, we offered the right of choice to the Soviet side. They have more accurate criteria for appraisal.

Flight director Valeriy Ryumin reported that the launch is planned for the end of next July. The programs of this individual expedition are rich with various experiments: on natural history, geophysical, technological and medical experiments. Specialists of the Soviet Union and Syria are taking part in their preparation and also in the elaboration of apparatus.

[Ryumin] We are planning that before the flight of the Syrian crew an astrophysical module will be docked with the "Mir" station and work will be carried out. This will include a complex of scientific research using apparatus installed on it. This is astrophysics, mainly.

[Galkin] A question was asked: How did the backup crew take the fact that they won't be flying into space? Munir Habib said: I will behave as a member of the backup crew just as if I were working as a member of the main one. Moreover, situations do occur when the backup crew becomes the main one. [Video shows Habib speaking]

[Solovyev] Our crew will be ready in such a way that it will be fully prepared and will be found to be as good as the first crew.

[Galkin] Correspondents inquired as to whether any of the backups of previous international crews would succeed in realizing their dream.

[Leonov] All backup cosmonauts, representatives of countries who flew on our spaceships, have not broken with space; on the contrary, they have become great specialists, scientists in that area, and at present anyone of those who were backups in the past, in general, in our view, can take up a place in a spaceship according to his level of training. Two representatives of France, Jean-Loup Chretien and Michel Tognini are currently in the Soviet Union undergoing training. They have already started training. At the beginning of January two representatives of Bulgaria will arrive in the Soviet Union. One of the candidates for this place is Aleksandrov, a former research cosmonaut and backup. Of course we would like him to pass the repeat medical competition and to join this group.

[Galkin] The Syrian pilots told the journalists about life and work in Zvezdnyy Gorodok, and expressed gratitude to specialists in the Cosmonaut Training Center for their help in coming to grips with a complicated profession. The forthcoming joint work of scientists and specialists and cosmonauts under the flags of the USSR and the Syrian Arab Republic, they stated, will become an important landmark in the peaceful mastering of space. [Video shows lineup of those holding the press conference]

/9274
CSO: 1866/35

SOVIET-FRENCH MEETING ON PLANS FOR 1988 JOINT MANNED MISSION

Moscow IZVESTIYA in Russian 6 Oct 86 p 3

[Text] A meeting of Soviet and French specialists took place in Moscow from 30 September to 4 October. The meeting was devoted to preparations for conducting a joint Soviet-French space mission in 1988.

In the course of the meeting, the sides outlined further details of a program of joint scientific-technical experiments on board the orbiting complex "Mir." Questions of the medical support of the mission and the training of French cosmonauts at the Cosmonaut Training Center imeni Gagarin were discussed. The sides reached agreement in regard to cooperation in informing the public on the course of preparations for the joint Soviet-French space mission and on the conduct of the mission.

Jean-Loup Chretien, France's first cosmonaut, took part in the meeting.

FTD/SNAP
/8309
CSO: 1866/45

MEMORANDUM ON 1988 SOVIET-BULGARIAN MANNED MISSION SIGNED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 23 Aug 86 p 1

[Text] A memorandum regarding preparations for a joint Soviet-Bulgarian manned space flight on the orbiting scientific complex "Mir"--"Soyuz," to be carried out in 1988, was signed in Moscow on 22 August.

The memorandum was signed by A.I. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research, for the Soviet side; and by M. Dakov, vice-president of the Bulgarian Academy of Sciences and chairman of the National Committee for Research and Use of Outer Space, for the Bulgarian side.

FTD/SNAP
/8309
CSO: 1866/45

DEVELOPMENT OF REPAIR OPERATIONS IN ORBIT

Moscow APN: ADVANCES OF SCIENCE AND TECHNOLOGY in English No 15, 5 Aug 86 pp 5-9

[Article by Mikhail Chernyshov: "Maintenance and Repair in Outer Space"]

[Text] Aircraft are not repaired in the air. Other vehicles too have special facilities to maintain them in: docks, sheds or garages.... Space vehicles were initially expendable, and the very idea of repairing them in orbit seemed absurd. But as time went on, with service life of satellites and duration of manned flights increasing, practice altered the old views on the repairability of space hardware: indeed, what is more preposterous than a situation when a minor malfunctioning puts a costly and complicated piece of machinery out of action?

"Generally speaking, everything we have done and will continue to do in space," says cosmonaut Vladimir Dzhanibekov, "has been and will be determined by past experience, the flight experience of all cosmonauts. In each case there was something that could not be done before and became possible after a mission flown. This transition from the forbidden to the allowable is the rule governing our advance, our storming of the barrier of the unknown."

Vladimir Dzhanibekov and Viktor Savinykh, aboard orbital station Salyut-7 in 1985, were faced with perhaps the most challenging of all repair operations ever undertaken by cosmonauts. We will take this subject up again later on, while now we merely trace the chronicle of repair jobs done during manned missions.

It is hard to say who of the cosmonauts embarked upon the career of a space repairman and when. It could have been Alexey Leonov during his first space walk, or Valeriy Kubasov when he conducted the first welding operation in orbit, or perhaps it dates from 1970 when cosmonauts Andrian Nikolayev and Vitaliy Sevastyanov, as they readied for the record 18-day mission aboard Soyuz-9, a record for that time, for the first time took along a small set of tools for possible minor repairs.

As orbital stations were developed, especially their second generation, their repairability was given more attention during all stages, from conceptual design to experimental testing on rigs. This was due to two reasons. First,

stations themselves became incomparably more sophisticated: Salyut-7, for example, incorporates over a thousand and a half devices, blocks, and instruments, about a score of panels, seven control posts and hundreds of electric drives. Secondly, stations have elements, such as storage batteries or atmosphere regeneration units, whose service life is known to be shorter than the expected life of the station. Consequently, the possibility of their replacement had to be taken into account beforehand. Soyuz-9 had an instrumental payload of less than a kilogram, while Salyut-7's instruments weighed several dozen kilograms.

Some of the space instruments were developed with an eye to specific space conditions--weightlessness and other factors. Nevertheless, almost all of them could be successfully used in terrestrial conditions as well. "For work in orbit," says Viktor Blagov, assistant space flight director, "we have a reaction-free hammer, which literally sticks to a nail, screw drivers that do not release screws gripped by them, a self-drawing auger that need not be pressed all the time, and pliers that increase a hundredfold the effort applied...."

Many industrial enterprises, research institutes, the Flight Control Center and Star city take part in developing space instruments and working out repair technology. Some of the units and devices have not yet been used in assembly or repair operations but have only been tested in space. They are tools of the future. Among them are, for example, what is known as an all-purpose hand-operated tool tested in free space by Svetlana Savitskaya and Vladimir Dzhanibekov. It is a rather complicated plasma burner which can cut, weld and solder metals and deposit various coatings on their surface by plasma method.

"Practice has shown," says Svetlana Savitskaya, "that moving in free space and working there even in an advanced spacesuit is still a difficult thing. The most inconvenient actions are those that require minute but precise manipulations. In open space, for example, I found it much simpler moving a large container with the burner than opening and closing a small safety lock...."

In recent years cosmonauts have been performing, both inside and outside their stations, operations never dreamed of before. On Salyut-6, for instance, Valeriy Ryumin and Vladimir Lyakhov, at the end of their six-month expedition, emerged into free space, walked along practically the entire length of their orbital complex on the outside and freed the station's docking unit from the entangled 10-meter dish of the radio telescope.

On the same station, Leonid Kizim, Oleg Makarov and Gennadiy Strekalov stripped open the hydraulic system and restored the circulation of the heating agent, something previously believed impossible to do in space.

On Salyut-7, Vladimir Lyakhov and Alexandr Alexandrov were the first to carry out a scheduled operation of adding more solar panels to the old ones. Later on, such operations were performed by other crews as well. In the course of their 237-day flight on the same station in 1984, cosmonauts Leonid Kizim

and Vladimir Solovye made five space walks to find and disengage a faulty section of the combined propulsion unit. In their work the cosmonauts employed 35 various tools, some 90 percent of which had been recognized as inventions and granted author's certificates.

In June 1985, it was in a dramatic fashion that Vladimir Dzhanibekov and Viktor Savinykh started their work in orbit. The cosmonauts had to land on a "silent" station. Owing to some fault in the power supply system Salyut-7 ceased obeying radio commands from the Earth and was sending no telemetry back. Entirely new techniques were developed for approaching the uncontrolled station and docking with it.

"We were learning to fly with new instruments, according to new methods and in new conditions," says Dzhanibekov. "The docking of our transport ship with the station has proved that it is possible to approach unmanned satellites for their inspection and necessary repair and maintenance work. It is of special significance in solving the problem of saving the crew of a manned ship that cannot return to the Earth because of its failed on-board systems."

It may be added that it was these techniques, first tried out by Dzhanibekov and Savinykh, which have been recently employed by Kizim and Solovyev for transferring from the Mir station to Salyut-7.

As they boarded the station, Dzhanibekov and Savinykh found that lack of power supplies had frozen many of the systems. Gingerly and cautiously, the cosmonauts worked their way through all the misalignments. This unprecedented repair saga had taken them more than a month. The world press called it "a space feat".

Salyut-7 has been in orbit since April 1982. Leonid Kizim and Vladimir Solovyov were the last to work on it before returning to the Mir station.

The first ever leap from one station to another is, according to specialists, of great significance as far as space research prospects are concerned. The way is being slowly paved for an entirely new stage--large-scale construction of space facilities and establishment of space-based manufactures. The placing in orbit of the Mir station, having six docking ports and offering a wide choice of working modes with attached specialized modules and independent spacecraft, marks the beginning of this phase. But this phase will yet require a multitude of transport operations to try out cargo flow patterns and also master new repair, maintenance, assembly and other jobs.

/6662
CSO: 1852/4

SPACE SCIENCES

STATUS OF ORBITAL ASTRONOMY PROJECTS

Moscow TRUD in Russian 25 Oct 86 p 3

[Article by Ye. Nelepo, associate of the USSR Academy of Sciences' Institute of Space Research]

[Abstract] The article reports on plans for orbiting spacecraft with telescopes for radio, gamma- and X-ray astronomy. Some of the projects involve participation of other countries.

According to I. Strukov, head of a department of the USSR Academy of Sciences' Institute of Space Research, one project for orbiting a radio telescope represents an extension of the experiment to detect relict radiation surviving from the Big Bang that was begun on the "Prognoz-9" satellite. The telescope on that satellite was able to distinguish two points whose temperatures differed by only ten-thousandths of a degree. On the new telescope, cooling of the antenna and radiation detector will increase the sensitivity of the instruments by 3-4 times.

Another radio astronomy project will involve an interferometry system of interactive ground and space telescopes. The telescope in space will reach an apogee of hundreds of thousands of kilometers. It will open and close automatically, with rigid shielding panels made of a special composite material. One of the main objects of study with this system will be quasars, but it is mentioned that it will also be used to measure coordinates of points on the Earth's surface for such purposes as studying continental drift and detecting earthquake precursor phenomena.

An X-ray observatory is being developed for the orbiting station "Mir." It will consist of four main X-ray telescopes and three auxiliary instruments. Scientists of the Netherlands, West Germany, Great Britain and the European Space Agency have taken part in the development of these telescopes.

The project of another orbiting observatory, which is called "Granat," has participation of French scientists. According to corresponding member of the USSR Academy of Sciences R. Syunyayev, head of the department of high-energy physics of the Institute of Space Research and scientific director of the

project, this observatory will permit measurement of hot plasma in clusters of galaxies, X-ray pulsars, and regions surrounding black holes. The "Granat" also will be used to investigate cosmic gamma bursts. It will be mounted on a rotating platform for quick aiming at a source of radiation.

Finally, a project called "Gamma-1" calls for an orbiting observatory with the world's largest gamma-ray telescope, plus an X-ray telescope and a telescope for observing soft gamma rays. This project is said to be the result of many years of Soviet-French cooperation involving experiments on satellites and manned orbiting stations. Models of the telescope have been tested on high-altitude balloons and in laboratory units that simulate the space environment. It is mentioned that tests of a working model of the telescope in a particle accelerator in Troitsk were completed recently, and the actual flight telescope is now scheduled for testing in the accelerator.

FTD/SNAP
/8309
CSO: 1866/45

SPACE SCIENCES

UDC 629.015

STUDY OF EVOLUTION OF CERTAIN ASTEROID ORBITS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 15 Jan 85) pp 323-336

[Article by M.A. Bashkovyak]

[Abstract] A study is made of the movement of a point of zero mass in the field of gravity of a central body and a number of other bodies, assuming that the masses of the other bodies are small in comparison to the mass of the central body and that the other bodies move in near circular orbits with slight inclination. The variation of the elements of the orbits of the other bodies evolving under the influence of mutual gravitation is considered fixed. An expression is derived for the secular portion of the disturbing function. The orbital elements of asteroids not in the major asteroid belt are calculated. The calculated evolution of asteroid orbits is illustrated with specific examples of actual asteroids.

Figures 4, references 9: 7 Russian, 2 Western

6508/8309
CSO: 1866/141

SPACE SCIENCES

UDC: 629.7.4.631.82

PERIODIC SOLUTION OF HAMILTONIAN SYSTEMS AND THEIR APPLICATIONS TO SATELLITE DYNAMICS. PART I

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 10 Jan 85) pp 345-357

[Article by Yu.V. Barkin, A.A. Pankratov]

[Abstract] A study is made of the periodic solutions of a canonical system of differential equations with a special type of Hamiltonian containing arbitrary parameters. Necessary and sufficient conditions for periodicity of solutions are derived. The conditions of existence of major parametric periodic solutions are determined in normal and degenerate cases in problems of celestial mechanics. The theory which is developed is applied to the study of periodic rotating movements of a satellite at a triangular libration point.

References 10: Russian.

6508/8309
CSO: 1866/141

UDC: 629.7.4.631.82

STABILITY OF PERIODIC MOTIONS OF A SATELLITE AROUND THE TRIANGULAR LIBRATION POINT OF THE LIMITED ELLIPTICAL THREE-BODY PROBLEM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 16 Aug 84) pp 358-362

[Article by S.N. Lelyavin]

[Abstract] A study is made of the rotational motion of a satellite whose center of mass is located at triangular libration point L_4 of the limited elliptical three body problem under the influence of Newtonian gravitation of two bodies. Inequalities are derived expressing the necessary conditions for stability of the periodic solutions in explicit form. A figure illustrates the results of numerical study of the periodic solutions and conditions of stability derived in the article, noting stable solutions.

Figure 1, references 4: Russian.

6508/8309
CSO: 1866/141

SPACE SCIENCES

UDC: 531.352

ANALYTIC ALGORITHM FOR KHORI METHOD IN PROBLEM OF ROTATION OF A CELESTIAL BODY AROUND A CENTER OF MASS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 2 Sep 85) pp 363-368

[Article by A.V. Rodnikov, I.I. Kosenko]

[Abstract] In many cases the motion of celestial bodies can be studied within the framework of a limited statement of the problem in which the interaction of the translational and rotational motion is ignored and the bodies are considered absolutely solid. In this article the orientation of such a celestial body in space is determined by means of two rectangular systems of coordinates: the system in which the body performs translational motion, and a system whose axes are directed along the major axes of inertia of the body. An analytic algorithm is constructed for the case in which the moment of external forces relative to the centers of mass is slight in comparison to the characteristic values of angular velocity. The algorithm does not require inversion of Poisson's theories, but explicit variations of the transformed variables as functions of the initial variables are produced.

References: 5 Russian

6508/8309
CSO: 1866/141

SPACE SCIENCES

UDC: 629.783:531

MOVEMENTS OF A SATELLITE ASYMPTOTIC TO ITS POSITIONS RELATIVE TO EQUILIBRIUM IN CIRCULAR ORBIT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 2 Dec 85) pp 369-375

[Article by G.A. Shcherbina]

[Abstract] In the problem of stabilizing a satellite in the vicinity of its relative equilibrium, the existence of natural sets of satellite motions (which in passive flight bring the satellite as time passes to its assigned oriented position relative to equilibrium or carry it away from this position) is important for problems of satellite orientation control. This article demonstrates that such sets of motions do exist. They are asymptotic motions of the satellite relative to its center of mass.

Figures 4, references 4: Russian.

6508/8309
CSO: 1866/141

UDC: 629.7

OPTIMAL REORIENTATION OF A SPACECRAFT IN "ROCKING" MODE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 6 Nov 84) pp 376-379

[Article by I.V. Ioslovich]

[Abstract] A study is made of the problem of reorientation of a spacecraft with a limitation on the phase coordinate (kinetic moment) in the class of "rocking" trajectories. The solution is sought which is optimal in terms of the consumption of propellant.

Figures 3, references 12: Russian.

6508/8309
CSO: 1866/141

SPACE SCIENCES

UDC: 629.195.1

MOVEMENT OF TWO MATERIAL POINTS CONNECTED BY A FILAMENT UNDER THE INFLUENCE OF GRAVITY AND AMPERE FORCES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 21 Aug 84) pp 380-387

[Article by V.I. Komarov]

[Abstract] A study is made of a problem in which two bodies connected by a heavy, inelastic monofilament move in a circular orbit. The length of the filament is assumed short in comparison with the distance to the center of the orbit. A dipole with fixed magnetic moment is located at the center of the orbit, and a constant electric current flows through the filament. Equations of motion in the central gravitational and dipole magnetic fields are derived. The equilibrium configuration is determined. Forced oscillations of the filament are analyzed in the linear statement, excited by changes in the magnetic induction vector. The evolution of the orbit as a result of the ampere forces is studied. An example is presented of a satellite with a mass of 20 tons connected by a 10-km line carrying a current of 42.5 A to a second mass. Ampere forces are found to change the orbital parameters by 100 km in 112 revolutions.

Figures 2, references 5: 4 Russian, 1 Western

6508/8309
CSO: 1866/141

UDC: 629.197.2

ALGORITHM FOR COMPUTATION OF PARAMETERS OF FOUR-PULSE TRANSITIONS BETWEEN CLOSE NEAR-CIRCULAR ORBITS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 11 Mar 85) pp 400-403

[Article by A.A. Baranov]

[Abstract] The problem of transition between close, noncoplanar, near-circular orbits is solved in its linear statement. Motion is analyzed in a cylindrical system of coordinates, the pole of which is located at the center of attraction, while the major plane coincides with the plane of the orbit. The optimal four-burn transition is determined given fixed time of transition. A minimum estimate of the functional is presented allowing significant reduction of the time required to find the solution.

References: 4 Russian

6508/8309
CSO: 1866/141

UDC: 551.510.535.2

POSSIBILITY OF EXPERIMENTAL STUDY OF THE PHENOMENON OF ANOMALOUS IONIZATION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 23 May 85) pp 404-410

[Article by L. Bankov, A.A. Galyev, E.M. Dubinin, N.M. Podgorniy, and Yu. N. Potanin]

[Abstract] A study is made of the phenomenon of critical velocity, first defined by Alfven in 1954, arising in the upper atmosphere when clouds of neutral gas interact with a plasma in a transverse magnetic field. Xenon gas is used as the working fluid. The parameters of a potential physical experiment for which self-sustaining plasma beam discharges could be expected are determined. With injection at an altitude of 500 km of neutral xenon at 200 g/s, after 2-3 s when the leading edge of the propagating cloud has reached about 0.5 km, a plasma discharge is ignited. The energy source of the discharge is the kinetic energy of the beam of xenon positive ions relative to the surrounding oxygen plasma.

Figure 1, references 9: Western

6508/8309
CSO: 1866/141

UDC: 551.521.6

SPECIFICS OF A BURST OF KILOMETER RADIO RADIATION IN A FLARE OF 13 MAY 1981

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 15 Jan 85) pp 411-417

[Article by V.P. Grigoreva, V.S. Prokudina]

[Abstract] A powerful chromospheric flare developed on the sun on 13 May 1981. This article analyzes data obtained for this flare in the optical, X-ray and radio band from the "Prognoz-8" satellite. Radio radiation in the kilometer band was observed at 2160 to 114 kHz by the satellite, with several bursts of type III observed with rapid frequency drift. The burst during the maximum phase of development of the flare featured radiation at 2160, 1540, 1140, 780 and 540 kHz. The type of burst, amplitude and time are presented in tabular form for all these frequencies. The bursts observed during the flares of 13 and 16 May 1981 differed significantly, although the flares were of the same type.

Figures 2, references 12: 5 Russian, 8 Western.

6508/8309
CSO: 1866/141

SPACE SCIENCES

UDC: 550.388.2

INFLUENCE OF VARIATIONS IN MAGNETOSPHERIC ELECTRICAL FIELD ON STRUCTURE OF PLASMOSPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 28 Sep 84) pp 418-427

[Article by Ye. V. Voronov, I.A. Krinberg]

[Abstract] A study is made of the influence of various time variations of the electrical field of magnetospheric convection on the structure and dynamics of the plasmosphere and plasmopause. A model of the formation of the plasmosphere is presented. The restoration of the plasmosphere following a magnetic storm is described. The simple method used in this article determines that the distribution of plasma in the plane of the geomagnetic equator depends on the time which has passed since the previous emptying of the geomagnetic force tubes. Weakening of the magnetospheric electrical field leads to formation of a new plasmopause at a higher altitude, so that two or more plasmopauses may exist simultaneously. As the magnetospheric electrical field strengthens, the plasmosphere is extended for some time over both the day and night sectors. The plasmopause drops rapidly during such periods and a local maximum appears in the distribution of plasma density near the position of the plasmopause.

Figures 5, references 10: 5 Russian, 5 Western.

6508/8309
CSO: 1866/141

UDC: 523.037:525.7

FORMATION OF DECOMPOSING PARTICLES IN RECORDING APPARATUS ON A SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 1 Jul 85) pp 428-433

[Article by L.V. Kurnosova, L.A. Razorenov, M.I. Fradkin]

[Abstract] The Salyut-1, Cosmos-410 and Cosmos-443 satellites were able to analyze the distribution of time intervals between moments of arrival of cosmic radiation particles, thus recording delayed particles. The authors undertook a time analysis of charged particles recorded by a telescope using a time analysis system including a timer and double coincidence circuit. The instrument recorded charged particles of the energies of interest passing through the telescope, delayed coincidence of particles passing through the telescope which may have been caused by the decay products of secondary unstable particles in the Cerenkov detector of the telescope, and charged particles with energies of over 1 MeV. The results of measurement by this instrument on the Cosmos-443 satellite (orbital inclination 65.4°, perigee 211 km, apogee 325 km) are studied. The axis of the telescope was vertical during the recordings. A meson component apparently related to generation of radioactive isotopes in the detector are found.

Figures 4, references 2: Russian.

6508/8309
CSO: 1866/141

UDC: 551.510.535.2

ELECTROMAGNETIC STRUCTURES IN THE AURORAL LATITUDES ACCORDING TO INTERCOSMOS-BULGARIA-1300 SATELLITE DATA

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 27 Mar 85) pp 434-439

[Article by E.M. Dubinin, P.L. Izraylevich, N.S. Nikolayeva, N.M. Podgorniy, N. Bankov, L. Todoriyeva]

[Abstract] An analysis is presented of intensive electromagnetic disturbances recorded in the auroral area at an altitude of about 900 km and an attempt is made to determine the general regularities in the structure of these disturbances. A class of events is found of similar form and it is shown that these disturbances result from interference of localized Alfven waves of great amplitude. The absence of any obvious correlation among the mutually perpendicular components of the electric and magnetic fields results from a significant phase shift between the disturbed electric and magnetic fields, indicating interference of incident waves and waves reflected from the ionosphere.

Figures 4, references 24: 6 Russian, 18 Western.

6508/8309
CSO: 1866/141

UDC: 550.385.41

MODELING OF ION COMPOSITION OF THERMOSPHERE BASED ON MASS SPECTROMETRIC MEASUREMENTS ON VERTICAL-6 ROCKET

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 29 May 85) pp 440-447

[Article by O.P. Krasitskiy, V.A. Yershova, V.A. Kochnev]

[Abstract] The purpose of this work was to construct a theoretical model of the composition of the terrestrial ionosphere based on data on the neutral composition obtained in an experiment using the Vertical-6 rocket, and to compare the calculated profiles of ion concentration produced by the model with ion concentrations measured in the same experiment. The model is constructed in the approximation of photochemical equilibrium at 130-230 km altitude. The calculated ion concentration profiles are compared with experimental profiles for O^+, $O^+(^2D)$, $O(^2P)$, O_2^+, $O_2^+(^4\Pi)$, N_2^+, N^+, NO^+, and He^+ ions. Calculated and experimental results agree satisfactorily.

Figures 3, references 24: 5 Russian, 19 Western.

6508/8309
CSO: 1866/141

SPACE SCIENCES

UDC: 612.014

RESULTS OF DOSE MEASUREMENT ON 'PROGNOZ' SPACECRAFT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 17 Jul 84) pp 455-458

[Article by N.V. Zhuravleva, I.A. Muratova, V.P. Petrov, V.I. Shumshurov]

[Abstract] The "Prognoz 5-8" spacecraft performed measurements of cosmic radiation doses which were used in experimental studies of the variation of galactic cosmic ray dose as a function of solar cycle period and dynamic solar cosmic ray dose and were used in testing a model description of galactic cosmic radiation and methods of calculating doses of both types of cosmic radiation used to assure radiation safety to space flights. The "Prognoz" spacecraft spent up to 95 percent of their flight time outside the terrestrial radiation belts, eliminating the contribution of radiation by these radiation belts. The experimental data on radiation obtained during the first half of the 21st solar activity cycle with shielding of detectors typical of the sealed compartment of the spacecraft indicated a decrease in measured dose with the approach of the solar activity maximum of not over 30 percent between 1976 and 1981. Model estimates agreed satisfactorily with dose measurements. The increase in divergence between calculated and measured values during the maximum of solar activity probably resulted from defects in the model description of differential galactic cosmic ray spectra, requiring further studies and improvement of the description in the 30-1000 MeV range.

References 6: 5 Russian, 1 Western.

6508/8309
CSO: 1866/141

UDC: 551.521.8

SPECIFICS OF PENETRATION OF SOLAR PROTONS INTO TERRESTRIAL MAGNETOSPHERE DURING THE EVENT OF 24-25 April 1979

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 29 May 85) pp 468-471

[Article by G.A. Glukhov, Yu.P. Kratenko, Yu.V. Mineyev]

[Abstract] Data from the satellite Intercosmos-19 are used to study specifics of latitude profiles and dynamics of boundaries of penetration of solar cosmic ray protons with energy 0.9-8.0 MeV in comparison with the position of the outer boundaries of electron capture with energy at least 40 keV, 0.3-0.6 and 0.9-1.2 MeV. Data are obtained on the fine structure of the development of magnetospheric substorms and storms. It is found that during the phase of development of substorms (not storms, as was previously thought) the boundary of penetration of solar protons is lowered, as is the boundary of electron capture during the evening hours. It is shown that on the night side the boundary of penetration of solar protons coincides with accuracy within 1° with the boundary of electron capture with the exception of the 1.5-3 hours from the flare phase of a substorm, when protons are observed in the area of electron capture. The precipitation of protons at the moments of substorms is explained by the nonadiabatic nature of their motion, the strong pitch-angle diffusion and the interaction of protons with electromagnetic waves.

References 6: 5 Russian, 1 Western.

6508/8309
CSO: 1866/141

UDC: 520.383

TERRESTRIAL MAGNETIC EFFECTS CAUSED BY 'POLARIZATION' ELECTROJET

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 15 Feb 85) pp 474-476

[Article by B.M. Kuznetsov]

[Abstract] Previous works have presented measurements of ion drift velocity which can be used to calculate electric field intensity measured by the Cosmos-184 satellite. During several passages of the satellite on 3 November 1967 when the satellite was located approximately at the meridian of Leningrad, intense electric fields were recorded. This article attempts to compare the data from the satellite with measurements taken at Leningrad observatory. The geomagnetic effect of the polarization jet was found to be observable at subauroral latitudes in the form of positive disturbances in the H field component, the intensity and duration of which are apparently determined by the latitude localization of the jet and the electric field intensity. During more active periods, when the auroral oval expands toward the equator down to the middle latitudes, the magnetic disturbance at 55-57° results not only from the influence of strong electric fields, but also from an increase in conductivity of the ionosphere at these latitudes.

Figure 1, references 12: 5 Russian, 7 Western.

6508/8309
CSO: 1866/141

UDC: 629

DETERMINING OPTIMAL MEASUREMENT PROGRAM WITH RESTRICTIONS ON ERRORS IN ESTIMATING THREE PARAMETERS OF MOTION OF SATELLITE WITH DIURNAL PERIOD OF REVOLUTION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 22 Oct 85) pp 483-496

[Article by M.L. Kidov and L.M. Bakuma]

[Abstract] A formulation of the considered problem and a method for its solution in general form were validated and described by M.L. Lidov in an article entitled "Effective Algorithm for Solution of Problem of Choice of Optimum Measurement Program With Restrictions on Errors in Evaluating Several Parameters" in KOSMICH. ISSLED., Vol 23 No 4, p 499, 1985. The results of a numerical solution of the problem are now presented in the case of a seven-dimensional equation of state for determining the near-circular motion of a satellite. Specifically, the authors examine the case of choice of a measurement program for determining the parameters of motion of an artificial earth satellite with a diurnal period of revolution and an inclination $i = 65°$. The initial set of parameters used is measurements of range and radial velocity from two surface points in a time interval of 1.5 days (1.5 satellite revolutions). Three parameters of motion are determined: initial transversal displacement, initial rate of change of transversal displacement and a quantity proportional to the change in the period of motion. The program requires solution of three problems of generalized linear impulse trajectory correction (see earlier article), which can be reduced to a problem in linear programming which can be solved by the standard simplex method. On this basis it is shown that the algorithm proposed in the earlier article makes it possible to obtain a full qualitative picture for all possible restrictions on the dispersion of errors in evaluating the three mentioned monitorable parameters. The numerical solution has confirmed the effectiveness of this algorithm.

Figures 2, references 3: 2 Russian, 1 Western.

5303/8309
CSO: 1866/4

SPACE SCIENCES

UDC: 521.26.803.81

CONTROL OF SPACECRAFT MOTION IN NEIGHBORHOOD OF COLLINEAR LIBRATION CENTER IN RESTRICTED ELLIPTICAL THREE-BODY PROBLEM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86
(manuscript received 20 Nov 85) pp 497-512

[Article by P.Ye. Elyasberg and T.A. Timokhova]

[Abstract] In order to ensure solution of a number of space research problems it is desirable that a spacecraft hover for some time in the neighborhood of one of the collinear centers of libration L_1 or L_2 in the three-body problem that is situated close to the smaller gravitating body. The problem of control of motion for such hovering is analyzed using the osculating parameters method. This approach makes it possible to obtain solutions in a wide range of change of ξ (for the sun-earth system up to $\xi = 0.8$; ξ is the ratio of the maximum distance of the spacecraft from the libration center to the distance from the smaller attracting body to the libration center). This provides a sufficiently high accuracy for solution of practical problems which is limited only by the accuracy in knowledge of the forces operative on the spacecraft in orbit. The problem is solved for the case of spacecraft motion in the gravitational field of two spherical attracting bodies moving relative to one another in a Keplerian orbit. The method can be applied directly to the case of motion with allowance for the perturbing effect of other celestial bodies. The basis for the equations is the necessary integral condition that the spacecraft orbit does not emerge from a given neighborhood of the libration center. With this consideration taken into account a method is given for finding the restricted orbit by solving a system of equations of motion for the vehicle and also a method for computing the correcting impulses ensuring prolonged hovering in the restricted orbit.

Figures 6, references 12: 9 Russian, 3 Western.

5303/8309
CSO: 1866/4

UDC: 629.015+531.38

METHOD FOR COMPUTING SECULAR PERTURBATIONS OF ASTEROIDAL BODIES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 27 Nov 85) pp 513-526

[Article by M.A. Vashkovyak]

[Abstract] A method for computing secular perturbations of almost circular asteroidal orbits with small inclinations to the plane of the ecliptic and periods incommensurable with the periods of revolution of the planets is proposed. In PUBL. ASTRON. SOC. JAPAN, Vol 25, p 394, 1973, M. Yuasa provided solutions of pertinent nonlinear averaged equations with an accuracy to the squares of the perturbing masses of the planets and with allowance for the higher degrees of eccentricities and inclinations of asteroidal and planetary orbits. The objective of this study was an approximate solution of the nonlinear equations on the basis of a nonstandard expansion of the secular part of the perturbing function differing from the work of Yuasa in that it is the same for both the "inner" and for the "outer" variants of the problem. The derived expressions are particularly convenient for taking into account perturbations from an entire group of celestial bodies precisely because they are based on a unified representation of the secular part of the perturbing function. Comparative computations made by other authors by a numerical analysis method and the method proposed in this article revealed a satisfactory agreement of the results for a time period of 100,000 years. The relatively simple analytical formulas describe changes in orbital elements with time. A further increase in methodological accuracy would be possible by additional allowance for second-degree terms for planetary masses, eccentricities and inclinations of planetary orbits.

Figures 4, references 10: 8 Russian, 2 Western.

5303/8309
CSO: 1866/4

UDC: 629.782

COMBINED ALGORITHM FOR DETERMINING AND PREDICTING PARAMETERS OF MOTION OF ARTIFICIAL EARTH SATELLITES USING ADAPTATION METHOD

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 1 Mar 85) pp 564-574

[Article by V.A. Bartenev and A.K. Grechkoseyev]

[Abstract] An improved method is proposed for determining and predicting the parameters of motion of an artificial earth satellite when there are errors in the model of motion. P.Ye. Elyasberg earlier proposed a least squares method for obtaining more precise coefficients which could be used for predictive purposes, but the approach made it possible to increase accuracy only if the uncertainty of the model of motion is caused exclusively by errors in the coefficients of the mathematical model. This method cannot give the desired accuracy increase (or may even worsen accuracy) if there are perturbations operative on the motion of an artificial satellite which are close in nature to purely random or are poorly studied (called "unmodelable" perturbations). Other authors have used the adaptive dynamic filtering method which even in the presence of unmodelable perturbations makes possible a highly precise determination of the parameters of motion. However, this method is less effective than the least squares method for predictive purposes and therefore is less than adequate. Accordingly, a combined method is proposed for determining a satellite orbit which incorporates both the recurrent adaptive filtering method and the least squares method. First a reference trajectory is determined from measurements by the least squares method. Then the measurement data are processed by the recurrent adaptive filtering method and deviations of the evaluations from the reference trajectory are computed. In this process the unmodelable accelerations are approximated by a random Gauss-Markov process. The evaluations of the deviations from the reference trajectory at the times of measurements with use of the proposed s-functions are "extended" to the prediction interval and are added to the reference trajectory. The use of this combined evaluation method makes possible the desired increase in accuracy in determining the parameters of artificial earth satellite motion despite incomplete information on the motion model.

Figures 3, references 11: 10 Russian, 1 Western.

5303/8309
CSO: 1866/4

UDC: 550.385.41

MOTION OF PACKET OF SMALL-SCALE ALFVEN WAVES IN MIDDLE-LATITUDE PLASMASPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86
(manuscript received 21 Nov 85) pp 598-609

[Article by Yu.I. Galperin, A.S. Leonovich, V.A. Mazur and A.V. Tashchilin]

[Abstract] The equations of motion for a small-scale Alfven wave packet, averaged for the period of oscillations between conjugate ionospheres, are derived for the middle-latitude magnetosphere. These quite simple equations can be used conveniently in calculating motion of such a packet across the magnetic shells. The trajectory of motion is dependent on the distribution of thermal plasma in the magnetosphere and can shift considerably in the L-shells. A magnetohydrodynamic waveguide can exist at definite shells near L = 1.3, as is evidenced in an ionospheric-plasmaspheric model. The role of such waveguides can also be played by so-called "bubbles," plasma-poor tubes of force floating into the upper ionosphere at the latitudes of the equatorial ionospheric anomaly. The theory qualitatively, but not quantitatively, explains some observations. Further research should take into account nonlinearity, which may bring theory and experiments into better agreement. On the other hand, there are other possibilities for explaining such magnetohydrodynamic effects. It was postulated that satellite-observed noise at L-shells corresponding to the epicenters of earthquakes is the result of generation of oscillations in Alfven waveguides forming in the region of the equatorial ionospheric anomaly. Generation of wave guides may occur under the influence of fast magnetosonic waves formed in the ionosphere over the epicentral region. These waveguides may serve as resonators in which there is an accumulation of the energy of low-frequency oscillations generated over a long period of time by acoustic effects in the ionosphere over disturbance regions.

Figures 4, references 53: 34 Russian, 19 Western.

5303/8309
CSO: 1866/4

SPACE SCIENCES

UDC: 537.591.4.574.83

RELATIONSHIP BETWEEN ENERGY PARAMETERS OF SOLAR MICROWAVE BURSTS AND ELECTRON STREAMS IN INTERPLANETARY SPACE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86
(manuscript received 29 Nov 85) pp 610-619

[Article by V.F. Melnikov, T.S. Podstrigach, Viktoriya Kurt and V.G. Stolpovskiy]

[Abstract] A great volume of statistical data made it possible to analyze the interrelationship between solar cosmic ray (SCR) electrons and radio bursts, with emphasis on the interrelationship between the energy parameters of radio bursts in the centimeter range and the intensity of the electron component of SCR. A homogeneous series of events in SCR made it possible to define the conditions for escape of particles from the solar source and their propagation in interplanetary space. Unlike other studies, with respect to radio emission use was made of the parameters of microwave radio bursts at the frequency of the spectral maximum because the emission at this frequency is less sensitive to change of conditions in the flare region and its intensity more correctly characterizes the number of accelerated electrons. The correlation between the amplitude of the electron flux in a flare event and the amplitude of a cm-range burst increases with an increase in electron energy and for mean relativistic electrons with $E_e \geqslant 500$ keV attains ~ 0.8. The correlation between the electron flux and the radio emission flux integrated for a burst was linear with a value of the correlation coefficient ~ 0.9 when measurements are made for the spectral maximum, suggesting that SCR electrons and electrons responsible for radio burst generation are accelerated in a common process: the electrons escaping into space are accelerated near or in the source of the microwave burst. The efficiency of escape of such particles is not dependent on their total number accelerated during a flare, being approximately the same for both the weakest and strongest events.

Figures 4, references 11: 2 Russian, 9 Western.

5303/8309
CSO: 1866/4

SPACE SCIENCES

UDC: 521.1

ONE CLASS OF NEAR-EQUATORIAL INTERMEDIATE ORBITS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86
(manuscript received 14 Nov 85) pp 639-642

[Article by N.V. Kapitonova and Ye.L. Lukashevich]

[Abstract] A class of intermediate orbits, in the first case taking into account all perturbations from the second zonal harmonic of gravity potential, and in the second case also partially periodic perturbations from an arbitrary even zonal harmonic with the coefficient I_{2n}, $n \geq 2$, was proposed in an earlier study by the author (KOSMICH. ISSLED., Vol 21 No 4, p 634, 1983). These orbits are constructed by inversion of quadratures obtained as a result of integration of the equations of motion of a satellite in a gravity field with a given potential. The orbits constructed in the earlier study correspond to the first case of motion when the polynomial $\Phi(\xi)$ in the expression describing this potential has two real and a pair of complex roots. This article examines the second case, in which all the roots of the $\Phi(\xi)$ polynomial are real. A series of expressions is derived with an accuracy to terms on the order of the square of planetary oblateness. These expressions define a class of intermediate orbits which take into account all the perturbations mentioned in the article. Using these expressions it is possible to analyze the motion of an artificial earth satellite not only in near-equatorial orbits, but also along cylindrical trajectories whose planes do not pass through the center of mass of the planet and are parallel to the equatorial plane.

References 4: 3 Russian, 1 Western.

5303/8309
CSO: 1866/4

UDC: 581.521

ARTIFICIAL EARTH SATELLITE SIGNAL AMPLITUDES IN POLAR REGION DURING PERIOD OF WORLD MAGNETIC STORM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 2 Jan 85) pp 645-648

[Article by G.K. Solodovnikov, Ye.A. Vasilchenko, Yu.G. Ivanov, B.Yu. Nekrasov, V.M. Russkin and A.V. Shirochkov]

[Abstract] Observations of signals (f = 150 MHz) from the "Transit" artificial earth satellite in a polar orbit at an altitude of 1,000 km were made in April 1981 on the "Severnyy Polyus-22" drifting station. Mutually perpendicular antennas were used to lessen the influence of radio signal fadings caused by the Faraday effect. The signal level E(t) usually exceeded the noise level by more than 10 db. Statistical processing involved discrimination of the random component of the received radio signals, making it possible to estimate the index of scintillations, time correlation coefficient and spectral density of signal fluctuations. A strong world magnetic storm was observed during the period 10-15 April; the explosive and main phases of the magnetic storm consisted of a series of substorms. The overall picture of behavior of the statistical characteristics of fluctuations of amplitudes of satellite signals in the polar cap was not consistent with data obtained at auroral latitudes, where the index of scintillations had a clearly expressed diurnal variation with a minimum at daytime. It is postulated that this inconsistency is attributable to two simultaneously operative disturbance mechanisms of different physical nature: a polarity reversal of sectors of the interplanetary magnetic field and injection of particles of the daytime cusp at local midday.

Figures 3, references 6: 3 Russian, 3 Western.

5303/8309
CSO: 1866/4

SPACE SCIENCES

UDC: 581.521

INFLUENCE OF TRANSVERSE ELECTRICAL FIELD ON LONGITUDINAL ACCELERATION OF PARTICLES IN MAGNETOSPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 3 Jan 85) pp 648-652

[Article by Ye.V. Voronov and I.A. Krinberg]

[Abstract] A study was made of the longitudinal acceleration of particles in the magnetosphere caused by the joint influence exerted on particle motion by the transverse electrical field $E_\perp$ and the curvature of magnetic lines of force. It was assumed that particle collisions do not occur and that wave-particle interaction is absent. A specific drift approximation was used. An expression was derived for determining the longitudinal acceleration as a point of departure for determining the energy sources responsible for this phenomenon. It was found that the energy increment of longitudinal motion is attributable to the energy acquired by the particle as a result of its migration along the electrical field lines of force under the influence of centrifugal drift. Several examples are given to illustrate the importance of allowance for the longitudinal acceleration of particles in the magnetosphere. The first example is the ejection of thermal ionospheric ions from the polar cap into the tail of the magnetosphere (polar wind); the second is the passage of a charged particle through the neutral layer of the magnetospheric tail, where the curvature of the magnetic lines of force is sharply increased. The present of a transverse magnetospheric electrical field results in the longitudinal acceleration of a charged particle if it moves along a curved geomagnetic line of force. This effect results in an increase (by a factor of 2-3) in the energy of polar wind ions emerging from the ionosphere and an increase in the range of their ejection into the tail of the magnetosphere, as well as an increase in the energy of charged particles when they intersect the neutral layer in the tail of the magnetosphere.

Figures 3, references 6: 3 Russian, 3 Western.

5303/8309
CSO: 1866/4

SPACE SCIENCES

UDC: 539.165

REGISTRY OF HIGH-ENERGY ELECTRONS AND POSITRONS IN BRAZILIAN ANOMALY REGION ('MARIYA' EXPERIMENT)

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 8 Jan 86) pp 652-654

[Article by S.A. Voronov, A.M. Galper, M.V. Guzenko, V.A. Zhanibekov, V.G. Kirillov-Ugryumov, S.V. Koldashov, A.V. Popov, V.P. Savinykh, V.Yu. Chesnokov and N.I. Shvets]

[Abstract] The "Mariya" magnetic scintillation spectrometer was used aboard the "Salyut-7"-"Soyuz"-"Cosmos-1669" space complex in an effort to explain the mechanism of generation of high-energy electrons and positrons in the neighborhood of the Brazilian anomaly, their energy spectra, temporal and spatial characteristics. The "Mariya" instrument consists of a permanent magnet with a field strength $\sim$4 koe in the gap and a hodoscopic system of scintillation detectors for determining the direction of arrival of the registered particles, angle of deflection in the magnetic field and flight time of particles entering the instrument aperture. The spectrometer registered electrons and positrons in the energy range 3.0-150 MeV. Trapped particles with pitch angles close to 90° could be registered. About 1,000 particles were registered between mid-August 1985 and mid-September of the same year. The total intensity of electrons and positrons was 1120 ± 160 $m^{-2} \cdot s^{-1} \cdot sr^{-1}$. This experiment fully confirmed other investigations of this anomaly. The ratio of the number of registered positrons to the number of electrons in the magnetic anomaly was 0.3 ± 0.1, whereas outside the anomaly it was 1.8 ± 0.2. The total intensity in the anomalous region increased by a factor of 6 (electrons by a factor of 13.2 ± 2.3, positrons by 2.0 ± 0.6). Electrons thus constitute the main component in the electron-positron flux in the inner radiation belt. Acceleration processes remain unclear.

References: 10 Russian.

5303/8309
CSO: 1866/4

UDC: 524.1-65

COSMIC RAY FLUCTUATIONS DURING PERIODS OF DISTURBANCE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26 No 4, Jul-Aug 86
(manuscript received 24 Mar 85, after correction 29 Jan 86) pp 529-534

[Article by O.V. Gulinskiy, I.Ya. Libin and R.Ye. Prilutskiy, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences]

[Abstract] A description is given of a statistical approach to estimating the spectral density of cosmic rays under conditions of variability. The approach is applied to studying data on the intensity of cosmic rays during periods of disturbance. Considerable difficulties are encountered in estimating the spectral density of cosmic rays during periods of Forbush decreases and prior to them. In this case the process is nonstationary and results in distorted estimates of spectral density made for stationary processes. Studying the spectral density of cosmic rays makes it possible to obtain information on the interplanetary magnetic field. In the low-frequency region the spectral density of cosmic rays is described sufficiently well by a power function, but clearly segregated peaks are observed not only in the cyclotron resonance region, but over a broad frequency range. The traditional methods of estimating the spectral density based on a direct Fourier transform have a number of major shortcomings. The linear model of autoregression with a moving average (the ARSS model) and modifications of the Levinson-Derbin and Berg algorithms used to estimate the parameters of this model are discussed and are contrasted with the approach based on the concept of the instantaneous spectral density of a nonstationary process. These approaches were used to analyze variations of cosmic rays during periods of disturbance. The objectives were to test the serviceability of the algorithms when using actual data, and to construct a theoretical model making it possible to diagnose the process on the basis of routine processing of data. Data were used from the Utrecht and Kerguelen stations for the period of 7 to 24 September 1977. The behavior of solar and geomagnetic activity was fairly complex at this time. Forbush decreases with amplitudes of approximately two and five to six percent, respectively, were

observed in cosmic rays on 12 and 21 September. Data from the Utrecht station show that before 19 September peaks are observed at frequencies of $5.5 \cdot 10^{-4}$ and $1.3 \cdot 10^{-3}$ Hz and the low-frequency region has a form close to a power-law. Two 24-hour periods before the beginning of a Forbush decrease the spectrum changes to a form close to the power density of white noise, and a similar pattern is observed also for the Kerguelen station. Peaks originate again at the same frequencies in the power densities computed from the data of both stations, beginning with 19 September. The technique suggested makes it possible to diagnose 24 hours before the beginning of a Forbush decrease the approach toward the earth of the shock wave responsible for this phenomenon.

Figures 2; references 12: 8 Russian, 4 Western.

[19-8831]

/8309

UDC: 524.1:523.9

RECONSTRUCTION OF SOME CHARACTERISTICS OF ENERGETIC SOLAR PARTICLES AT SOURCE FROM OBSERVATIONS NEAR EARTH

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26 No 4, Jul-Aug 86 (manuscript received 18 Oct 85) pp 535-540

[Article by L.I. Miroshnichenko and M.O. Sorokin, Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, USSR Academy of Sciences]

[Abstract] The reconstruction on the Earth of characteristics such as the energy spectra, variation over time and anisotropy of accelerated particles directly at the source is necessary for a better understanding of the process of the acceleration of particles in solar flares and the dynamics of energetic solar particles (ESP's). A method was suggested in an earlier study (1985) for reconstructing the spectrum of the source from the observed variation over time of ESP's near the earth, by numerical solution of an integral equation with a specific kind of Green's function, representing the inverse problem of the propagation of ESP's. This method is applied to reconstruction of the time dependence of the intensity and angular distribution of ESP's as they are emitted from the source. A theoretical analysis is made of the time dependence of the emission of ESP's. It is demonstrated that it is possible to use the data of observations near the earth, in the energy range of approximately 0.5 to 10 GeV, for reconstructing the time profile of the emission of ESP's. The data on the solar proton event of 23 February 1956 demonstrate this well. According to these data, the time profile for the emission of particles with hardness of 3 to 4 GV is in the form of an asymmetric curve having a maximum which drops about 10 minutes after the start of the event. The data of observations made near the Earth, of the solar proton event of 7 May 1978, were used to reconstruct the pitch-angular distribution of ESP's near the source. In this event the energetic solar particles revealed rather strong anisotropy with respect to pitch angles. The angular distribution of relativistic protons at the moment of

emission proved to be symmetric relative to the position of the flare, and about half of the particle flux was concentrated within an angle of 36 degrees. The analysis made here demonstrates that the method suggested in 1985 provides important information on the energy, time and angular characteristics of energetic solar particles as they are emitted from the source. Also, the new method of reconstructing the time dependence of the intensity and angular distribution of ESP's as they are emitted from the source, based on the numerical solution of an integral equation and utilization of data on the time profile and anisotropy of ESP's close to the orbit of the Earth, has been validated.

Figures 3, references 14: 8 Russian, 6 Western.

[19-8831]

/8309

UDC: 550.388.2:521.81

EFFECTS OF SOLAR ECLIPSES IN OUTER IONOSPHERE: I. EXPERIMENTAL RESULTS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26 No 4, Jul-Aug 86
(manuscript received 16 Nov 85) pp 557-562

[Article by A.Ye. Indyukov, A.V. Tashchilin and M.D. Fligel, Siberian Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, Siberian Division, USSR Academy of Sciences, and Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences]

[Abstract] The disturbance of the equatorial ionosphere caused by a solar eclipse is characterized and analyzed on the basis of the results of measurements from the Intercosmos-19 satellite launched in February 1979 and designed for research on the outer ionosphere. Two solar eclipses (a total on 16 February 1980 and an annular on 10 August 1980) occurred during the satellite's period of operation. Both occurred over equatorial latitudes. Measurements were made of the electron temperature and energy spectra of electrons along the satellite's orbit. Distributions of electron concentration were calculated along the satellite's path from the level of the maximum of the F2 layer to the altitude of the satellite's orbit. For the total eclipse, it was difficult to isolate the effects directly caused by the eclipse, since it coincided with the development of the principal phase of a strong magnetic storm. The annular eclipse coincided with a prolonged magnetically calm period. During a solar eclipse, layers of the ionosphere react differently to the short-duration cutoff of sources of ion formation and heating in the upper atmosphere. In the E and F1 layers a solar eclipse is accompanied by a reduction in electron concentration and temperature. In the F2 layer and outer ionosphere the processes of the diffusion and drift transfer of electrons and thermal ions play an important role. The Intercosmos-19 data show the greatest reduction of electron concentration, in the region of the shadow, near the maximum of the F layer. The amplitude of this disturbance is reduced with an increase in altitude. The temperature of electrons remains unchanged at altitudes of 600 to 700 km during eclipses. Stable longitudinal variations in the equatorial anomaly were observed in the area of the Pacific Ocean under

undisturbed daytime conditions. It is suggested that this is associated with stable longitudinal differences in the rate of electrodynamic drift or the effect of the horizontal neutral wind. Data exist which point to the possibility of longitudinal variations in the drift rate during the day, and the effects of the horizontal neutral wind depend on longitude because of corresponding variations in magnetic declination. A detailed quantitative analysis of the mechanisms governing the behavior of the equatorial F2 region during a solar eclipse is left for an independent study.

Figures 4, references 17: 3 Russian, 14 Western.

[19-8831]

/8309

UDC: 550.388.2

ESCAPE OF RADIO WAVES FROM IONOSPHERIC CHANNELS AND DETERMINATION OF RAY DIFFUSION CONSTANT FROM AMPLITUDE RECORDS OF SATELLITE SIGNALS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26 No 4, Jul-Aug 86
(manuscript received 17 Dec 85) pp 581-588

[Article by D.S. Lukin and Ye.Ye. Tsedilina, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences]

[Abstract] By studying signals transmitted by satellites over very great distances it is possible to obtain data on the space and space-frequency characteristics of the long-range propagation of short radio waves in the ionosphere. Over great distances, greater than approximately 5 to 10 Mm, radio waves are propagated in ionospheric wave channels separated from the Earth and along ricocheting trajectories. With this, radio waves are scattered in inhomogeneities and this results in their regular spilling from the channel onto the Earth. An analysis is made of the real case of a horizontally inhomogeneous ionosphere. It is shown that comparison of the results of the analysis with the data of observations of satellite signals makes it possible to determine the effective constant for the diffusion of waves in the ionosphere resulting from scattering in inhomogeneities. An analysis is made of the recording of the field strength, characteristic of daytime conditions at the point of reception, obtained from the Vostok spacecraft at a frequency of 20 MHz on 12 and 13 August 1962 in the area of Moscow. The signal was received by a narrow-beam antenna with an effective lobe width of approximately 5 to 10 degrees at an angle of 5 to 10 degrees to the horizon. The transmitter had a nondirectional antenna. Large-scale fluctuations in amplitude with a period of 2 to 3 Mm are observed at a distance of $S < 7$ Mm from the reception point. It is shown that amplitude records of this type can be used to determine the ray diffusion constant, D. A calculation is made of the path along which the radio waves were propagated as the satellite moved away in an easterly direction from the point of reception. It is demonstrated that the fluctuations in amplitude observed can be explained only by the escape of radiation from an ionospheric channel separated from the surface of the Earth. The propagation of signals from the satellite to the

receiver is analyzed on the basis of a calculation in accordance with the EMI-81 model (global analytical equinoctial model of electron concentration of the ionosphere). An analysis is made of the mean variation in the amplitude of the signal, the altitude of the trajectory at each point along the path is calculated, and the mean field strength is estimated. It is demonstrated that the most probable explanation for large-scale fluctuations in the amplitude of the signal is related to the escape of radiation from an interlayer channel with the multiple scattering of the wave in inhomogeneities. It is concluded that amplitude records of satellite signals can be used to determine the value of the ray diffusion constant, but that calculation of the signal path is necessary in each specific case for the purpose of analyzing observations, for the amplitude of the signal can be increased or reduced as a function of the distance from the satellite under various conditions in the ionosphere.

Figures 4, tables 1, references 15: 13 Russian, 2 Western.

[19-8831]

/8309

UDC: 550.383

WAVE CHARACTERISTICS OF LOW-FREQUENCY EMISSION RECORDED ON OREOL-3 SATELLITE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 26 No 4, Jul-Aug 86
(manuscript received 19 Aug 85) pp 628-634

[Article by L.B. Volkomirskaya, S.A. Gorbunov, S.V. Panfilov and A.Ye. Reznikov, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences]

[Abstract] Synchronous measurements were made of three magnetic and two electrical components of the low-frequency wave field by means of the Oreol-3 satellite in 1981-1983 in a joint Soviet-French experiment. A study is presented of the wave characteristics of low-frequency emission from the data of measurements of three magnetic components in the frequency band of approximately 10 to 1300 Hz. The experiment was conducted at altitudes of 400 to 700 km, where the ionosphere can be described by a model of a cold magnetoactive plasma. The behavior of low-frequency waves in the ionosphere is determined by the type to which they belong, so a central problem was the determination of the polarization and wave normal of the low-frequency emission observed. In the frequency band studied, the emission recorded above the gyrofrequency of protons is right-polarized. Polarization relationships and the direction of the wave normal are determined by determining the amplitudes and phases of components of the electromagnetic field and combinations of them. The information recorded is assumed to describe a random process. Values of the spectral energy distribution are regarded as nonrandom characteristics of this process. The principal relationships are found, from the energy spectra of the components of low-frequency emission, for the behavior of wave normals and the wave distribution function as a function of the frequency and invariant latitude, L. It is shown that measurements in the frequency range of 300 to 1000 Hz can be analyzed in a plane-wave approximation, and that the frequency range in which this approximation is valid becomes larger with an increase in parameter L. At frequencies below the gyrofrequency of protons, i.e., where the plane-wave approximation is not valid, a second maximum often occurs in the wave distribution function, and this maximum can be interpreted as a reflected wave.

Figures 3, references 12: 4 Russian, 8 Western.

[19-8831]

/8309

UDC: 521.1:531.1

CONSTRUCTING OPTIMAL TRANSFER ORBIT WITH ALLOWANCE FOR ATMOSPHERIC DRAG, EARTH'S ASPHERICITY AND LUNAR AND SOLAR PERTURBATIONS

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 2, Apr 86 (manuscript received 1 Nov 84) pp 77-82

[Article by V.S. Novoselov and Ye.V. Shulyak, Leningrad State University]

[Abstract] An analytical theory for the optimal choice of a two-impulse coplanar transfer for certain cases of allowance for planetary asphericity, atmospheric drag and perturbations from external bodies was developed earlier by V.S. Novoselov in VESTN. LENINGR. UN-TA, No 1, pp 86-93, 1982; No 1, pp 92-99, 1983. That research served as a basis for the present work, the purpose of which is a synthesis of the mentioned perturbations for the specific case of analytical construction of an optimal two-impulse equatorial transfer between coplanar orbits with small eccentricities. The point of departure was the problem of transfer from a low orbit to the orbit of a stationary satellite. In the initial orbit the lift and lateral force caused by atmospheric drag are assumed to be negligible, with atmospheric density determined by an exponential dependence. The transfer orbit is considered in a great altitude range (200-36,000 km). At low altitudes the influence of atmospheric drag is important, whereas the influence of the sun and moon and gravity field asphericity are important. All three types of perturbations are taken into account in the transfer orbit. An algorithm is presented for zero-approximation optimization for a two-impulse transfer from a low near-circular orbit into a high near-circular orbit. Conditions are written for an impulsive change in velocity at the initial and final points, continuity of Lagrangian factors and the Pontryagin function. Boundary and transversality conditions are presented. In this formulation the problem is solved in both the first and second approximations.

References: 4 Russian.

5303/8309
CSO: 1866/10

UDC: 629.7.1.30.82

STRUCTURE OF HIGHER ORDER REGIONS OF RESONANCE IN ROTATION OF SATELLITE IN PLANE OF ELLIPTICAL ORBIT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86
(manuscript received 22 May 84) pp 9-14

[Article by Ye.M. Levin]

[Abstract] A satellite rotating in a plane travels in an elliptical orbit about a gravitational center and is subject to dissipative and gravitational moments. The equation of planar rotation is written in terms of its three primary central moments of inertia, the angle between the line to the gravitational center and the largest moment of inertia not perpendicular to the orbital plane as well as the gravitational constant of the attracting center, the current distance from the center, the eccentricity, the true anomaly of the satellite, the major axis of the ellipse, the angle between the largest axis of inertia and the direction to the pericenter of the orbit and the dissipative moment. It is assumed that the satellite is close to a state of dynamically symmetric rotation and the dissipative moment is a function only of the position of the satellite in the orbit and the angular rotational velocity. With type p:2q resonance rotation, the satellite makes p revolutions in the inertial space during 2q orbital revolutions. Point mappings are used to detail the structure of the higher resonance zones for q = 2 and 3. This region is similar to the structure of first order resonance regions and one of the higher order resonance effects is the gravitational stabilization of the satellite orientation relative to the inertial space. The author is grateful to professor V.V. Beletskiy for discussing the paper and his valuable comments.

Figure 1, references: 8 Russian.

[101-8225]
/8309

UDC: 531.01+629.195.2

PERIODIC RESONANT MOTIONS OF AXIALLY SYMMETRIC SATELLITE IN ELLIPTICAL ORBIT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86
(manuscript received 29 Mar 84) pp 15-23

[Article by P.N. Chekhovskaya]

[Abstract] An axially symmetric rigid body travels in an elliptical orbit in a central Newtonian gravitational field. The body (satellite) dimensions are small as compared to the orbit. In starting the analysis with the simple special case of a circular orbit, equations of satellite motion about the center of mass using a Hamiltonian function allow for a definite solution describing the conical precession. In the case of an elliptical orbit, the conical precession produces more complex motions. This paper analyzes the existence, structure and stability of such satellite motions close to conical precession, when the satellite has a period equal to the period of rotation of its center of mass and the orbits have near zero eccentricity. A method of analyzing 2π-periodic motions of Hamiltonian systems, when resonance is present in the forced oscillations, is used to analytically define the regions of resonance. The number of unknown periodic motions is found as a function of the values of the problem parameters (the nutation angle and a normalized inertial parameter). An explicit form of the periodic solution is found and the amplitude of the oscillations is determined as a function of the problem parameters. The author is grateful to professor A.P. Markeyev for the formulation of the problem and his valuable advice and constant attention to the work.

Figures 4, references 10: 9 Russian, 1 Western.

[101-8225]

/8309

UDC: 629.7.4.631.82

LIBRATION MOTION OF EQUATORIAL SATELLITE IN GRAVITATIONAL FIELD OF ASPHERICAL ROTATING PLANET

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 16 Aug 84) pp 24-29

[Article by V.A. Kitova]

[Abstract] The averaging method of Delon and Hill is used for the construction of the intermediate orbit of an equatorial satellite of a rotating planet with different dimensions along its three axes. The planet rotates at a constant angular velocity about a stationary axis running through the smallest axis of inertia of the planet and the periods of rotation of the satellite and the planet are closely commensurate. Analytical expressions are derived for the orbital elements of resonant equatorial satellites. The major resonance effects in the satellite motion appear in the form of oscillations with a period proportional to $m^{-1/2}$, where $m^{-1/2}$ is the degree of compression of the planet. The average motion of the satellite, the major axis of the orbit and its eccentricity also experience oscillations close to their own resonant values. These resonant values do not undergo secular changes and the argument of the pericenter of the orbit changes in secular fashion at a constant rate and simultaneously experiences oscillations with a defined period. The averaged differential equations of motion allows for a family of periodic solutions and the solution conditions are specified. The influence of third and higher harmonics of the power function is manifest only in third and higher order perturbations relative to $m^{-1/2}$.

References: 2 Russian.

[101-8225]

/8309

UDC: 629.78

APPLICATION OF LOCAL POLYNOMIALS TO PROBLEMS OF ESTIMATING DYNAMIC SYSTEM PARAMETERS FROM OBSERVATIONAL DATA

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 26 Apr 84) pp 30-38

[Article by A.V. Brykov]

[Abstract] In problems of estimating parameters of dynamic systems, such as those involving missile and space navigation systems, simplification can be achieved by use of local polynomials that approximate the most complex functions while providing the best trade-off between speed and approximation precision. A fundamental question is the optimization of the choice of the approximating polynomial parameters. This is usually based on the estimation of the approximation precision of the random functions using measurement data from actual full-scale physical observations. This paper is a mathematical analysis of this optimization process that relys heavily on matrix algebra for the derivation of the general mathematical relations determining the dynamic system parameter estimation errors due to imprecise knowledge of the expectation value of the function under study. Such estimation errors are in certain cases shown to be many times greater than the ultimate errors arising from all other perturbing factors. A crucial factor in the appearance of the expectation value estimation error is not the absolute value of the difference between the expectation of the unknown function assumed for the calculation and its true value, but rather the presence of periodic components in this difference. The use of local polynomials to generate correct estimates from observational data requires the consideration of the presence of errors in the knowledge of the expectation value of the approximating functions.

Figures 2, references: 4 Russian.

[101-8225]

/8309

UDC: 629.78

ANALYTICAL STUDY OF DISPERSION OF SPACECRAFT DURING ATMOSPHERIC DESCENT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86
(manuscript received 31 May 83) pp 39-45

[Article by O.A. Privarnikov]

[Abstract] Analytical estimates of the dispersion of uncontrolled spacecraft when descending in the atmosphere are usually obtained by approximate integration of the equations of motion in variations for relatively rectilinear Allen-Eggers trajectories, which are valid for the linear braking phase of a ballistic spacecraft. This paper proposes a different approach using approximate integration of a system conjugate to the variation equations of motions that generates estimates in simpler form and substantially improves their precision. Analytical estimates are derived for the spacecraft dispersion due to the deviation of atmospheric parameters from the nominal, the scatter in the drag coefficient, oscillations of the craft relative to the center of mass and the displacement of its center relative to the longitudinal axis during such an uncontrolled descent. The method is illustrated with an application to a descent with a constant trajectory inclination angle; the error in calculating range deviations using the proposed analytical formulas does not exceed 20 percent as compared to the 5 to 10 percent error in previous machine methods. The method is also applicable to estimation of the range deviation for a controlled descent and this construction of analytical estimates significantly facilitates the solution of the inverse problem of selecting the control system and its parameters with specified constraints on the dispersion of the ground impact point.

Tables 2, references 8: 6 Russian, 2 Western.

[101-8225]

/8309

UDC: 521.1

ORBITS WITH PERIODIC LUNAR FLYBYS AND THEIR APPLICATION TO VERY LONG BASELINE RADIO INTERFEROMETRY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 25 Jun 84) pp 52-57

[Article by A.Yu. Kogan]

[Abstract] The orbit of a satellite used as one terminus of a very long baseline interferometry system can be characterized in terms of the area swept out by the baseline F, described mathematically in terms of the observation intervals, the unit vector directed towards the target and the kinetic moment vector of the satellite. The integral function for F, which takes into account the linear dimensions and rate of evolution of an orbit, is used as a quality criterion for the selection of an unusual satellite orbit for VLBI: an orbit with periodic close flybys of the moon, where the least planar orbits are optimal. This paper mathematically analyzes the orbits that satisfy F-optimality conditions, with the additional constraint that the orbit must be achieved with a single impulse. This impulse is practically the same as the minimal impulse needed to reach the moon (the latter is only 20 to 40 m/s less than the former). The orbital parameters are summarized in tables.

Tables 2, figure 1, references 6: 3 Russian, 2 Western, 1 Western in Russian translation.

[101-8225]

/8309

UDC: 629.7.018.3

RADIATIVE HEAT TRANSFER OF METEOROID IN RADIATIVE THERMAL CONDUCTIVITY APPROXIMATION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 2 Jul 84) pp 58-68

[Article by N.N. Pilyugin and T.A. Chernova]

[Abstract] At Mach numbers above 30 and with moderate to large Reynolds numbers, the primary mechanism for heat transfer to a solid is radiative heating. While approximations have been found in recent years for the radiative heat transfer of a blunt solid traveling in the earth's atmosphere, such relations are valid only in a relatively narrow range of variation in the velocity and density of the inflowing gas and the body size. A "thick-thin" approximation of radiative heat transfer covers a broader range of parameters but requires more computer time for the determination of the spectral properties of the gas around such a meteoroid. This paper first formulates the problem of hypersonic flow around an axially symmetric blunt solid with a nonviscous gas flow, taking radiative transfer in the shock layer into account in a "thick-thin" approximation. By using the hypersonic approximation and a locally self-consistent model, a solution is found by combining asymptotic expansions for the case when a large solid is exposed to a flow of an optically thick gas. A formula is derived for the radiative heat transfer coefficient and specific features of the heat transfer to such large solids are noted. The authors are greateful to L.I. Sedov and G.A. Pirskiy for discussing the results of the paper and to E.Z. Apshteyn for his useful comments.

Figures 4, references 20: 16 Russian, 2 Western, 2 Western in Russian translation.

[101-8225]

/8309

SPACE SCIENCES

UDC: 523.72

DETERMINATION OF ELECTROSTATIC POTENTIAL JUMP AT NEAR-EARTH SHOCK WAVE FRONT FROM SELECTIVE MEASUREMENTS OF ION COMPONENTS OF SOLAR WIND

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 10 Apr 85) pp 69-78

[Article by G.N. Zastenker and A.A. Skalskiy]

[Abstract] The Prognoz-7 (November 1978 to July 1979) and Prognoz-8 (December 1980 to September 1981) satellites had 96-hour orbits that intersected the near-earth shock wave at least twice per orbit. The on-board multichannel spectrometers made both nonselective measurements of the ion component of the solar wind and selective measurements of the energy spectra of protons and alpha particles. The measured energy range was 250 to 5,000 eV/q with an energy resolution of 5 to 7 percent, an angular pattern width of 2 to 4° and a mass to charge ratio selectivity of no worse than 10^{-3} with a single energy spectrum measurement time of about 246 s. Interplanetary magnetic field data were provided both by an SG-70 magnetometer for the Prognoz-7 and by ISEE-3 instrumentation for correlation with the Prognoz-8 measurements. The data are used to determine the energy balance, which in turn defines the electrostatic potential jump at the shock wave front. This jump varies in a wide range from about 40 eV to more than 900 eV with an average value of 300 ± 32 eV. It comprises from about 5 percent to 70 percent of the energy of the directional motion of the protons in the solar wind and qualitatively agrees with numerical calculations in the literature. A comparative analysis of the jumps in the parameters of the protons and alpha particles at the front shows that in about 60 percent of the intersections of the satellites, the kinetic energy loss per unit charge for alpha particles is double that of the proton energy losses, i.e., the velocities of the components following the shock wave front are about the same. In the remaining case, the energy losses per unit charge are approximately the same. The temperature jump of the alpha particles in all events was several times greater than that of the protons, the average ratio being about 3.5. The authors are grateful to many colleagues for assisting in the experiment and data reduction, as well as to O.L. Vaysberg and V.N. Smirnov for their extremely fruitful discussion of the results.

Figures 6, references 16: 4 Russian 12 Western.

[101-8225]

/8309

UDC 551.521

VARIATIONS IN IONOSPHERIC PLASMA CONCENTRATION IN REGION OF MAIN IONOSPHERIC TROUGH DURING MAGNETIC STORM OF 18-19 DECEMBER 1978 IN CONNECTION WITH INTERPLANETARY MAGNETIC FIELD CHANGES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 7 Mar 85) pp 79-87

[Article by G.L. Gdalevich, A.Yu. Yeliseyev, O.P. Kolomiytsev, V.V. Afonin, V.D. Ozerov, and T.N. Sobeleva]

[Abstract] Positive ion concentrations were measured at an altitude of 500 km in the northern hemisphere by the Cosmos-900 satellite on 18-19 December 1978. The magnetic storm at this time produced an ionospheric perturbation during which clearly manifest movement of the main ionospheric trough was observed in the morning and evening sectors. The behavior of the trough differed greatly in these two sectors and the motion of the isolines occurred simultaneously at the majority of latitudes. The variations in the ion concentrations in the evening sector at the equatorial edge of the trough correlate with the B_z component of the interplanetary magnetic field. In the morning sector the trough is located at lower latitudes than in the evening sector and is apparently "residual," i.e., bears traces of the perturbation that occurred in the evening sector. A clear correlation is observed between the development of the ionospheric disturbance and variations in the interplanetary medium parameters, in particular, with the $E_y = -VB_z$ component of the interplanetary electric field. A detailed schematic drawing shows the formation of the main ionospheric trough and explicates the major features of the shape and motion of the trough in both the morning and evening sectors.

Figures 5, references 30: 17 Russian, 13 Western.

[101-8225]

/8309

SPACE SCIENCES

UDC: 581.521

STOCHASTIC INSTABILITY OF CHARGED PARTICLES IN GEOMAGNETIC TRAP

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86
(manuscript received 5 Sep 84) pp 88-96

[Article by V.D. Ilin, I.V. Ilin, and S.N. Kuznetsov]

[Abstract] The motion of charged particles trapped in a geomagnetic field is governed by three periodicities related to Larmor rotation, longitudinal oscillations and drift rotation around the earth. Adiabatic integrals of motion describe these oscillations, which are nonlinear by virtue of the dependence of their frequencies on the magnetic moment of the particles. The degree of stability of the particle motion depends on how well the adiabatic invariants are preserved. Failure to preserve the invariants can result in nonlinear resonance between particle oscillations in various degrees of freedom. Resonances between Larmor rotation and higher harmonics of the longitudinal oscillations are the most dangerous in terms of stability loss since they cause irreversible changes in the particle magnetic moment during repeated passages through the magnetic field minimum. Various types of stochasticization of the trajectories of charged particles are possible, depending on the changes in the magnetic moment during long longitudinal oscillations. This paper analyzes the various kinds of stochastic instability of such trapped particles; the boundaries and limits of instability occurrence are defined and the nonadiabatic behavior of the particles is explained by means of a new loss mechanism related to this stochasticization of particle motion which plays an important part in the overall leakage balance. This mechanism explains not only the observed features of the spatial distribution of high energy protons, but also predicts such new phenomena as a discrete structure of the angular and energy spectra of the protons, inflection points in the particle spectra corresponding to the boundary between Arnold diffusion and diffusion modulation, as well as the existence of a comparatively extensive unfilled region of global stochastic behavior in which the proton fluxes are below the space background level.

Figures 4, references 15: 10 Russian, 3 Western, 2 Western in Russian translation.

[101-8225]

/8309

UDC: 551.521.8

DISTRIBUTION FUNCTION AND COEFFICIENT OF RADIAL DIFFUSION OF ELECTRONS FOR L = 1.2 TO 1.4 FROM INTERCOSMOS-19 SATELLITE DATA

Moscow KOSMICHESKIYE ESSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 21 Sep 84) pp 97-105

[Article by G.A. Glukhov, Yu.I. Gubar, Yu.V. Mineyev, I.N. Senchuro, and P.I. Shavrin]

[Abstract] During March-August 1979 the "PERO-ZI" spectrometer on board the Intercosmos-19 satellite made measurements of the energy spectra and pitch angle distributions of electrons at energies of 0.3 to 2.0 MeV for L = 1.2 to 1.4. The May data were used to construct the distribution of electrons of natural origin for these values of L. Radial diffusion from the region where L is greater than 1.4 is the source of these electrons. The radial diffusion coefficient D_{LL} is found for this case; for electrons with a magnetic moment of M = 20 MeV/gauss at L = 1.2, the diffucion coefficient is $D_{LL} = D_0L^6 = 9 \cdot 10^{-6}$/day; for L = 1.4, $D_{LL} = 2.2 \cdot 10^{-5}$/day. The nature of the electron lifetime as a function of M indicates that for L less than 1.23, the lifetime is primarily governed by Coulomb losses, while for larger values of L, resonant interaction of the electrons and waves is significant.

Figures 6, references 16: 3 Russian, 12 Western, 1 Western in Russian translation.

[101-8225]

/8309

SPACE SCIENCES

UDC: 538.561

COMPARISON OF CALCULATED AND MEASURED SPECTRAL PARAMETERS OF WHISTLERS FOR 'ARAKS' EXPERIMENT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86
(manuscript received 6 Dec 84) pp 139-143

[Article by N.I. Izhovkina, S.A. Pulinets, and Ye.P. Trushkina]

[Abstract] A series of electron pulses was injected into the ionosphere in the "Araks" experiment (the electron injector operated at energies of 27 and 15 keV and the electron pulse current was $I_0 = 0.5$ A) for various initial electron pitch angles. Wave emissions were measured in a frequency range of 0.1 to 5 MHz and the low frequency components were discriminated by means of a broadband filter with a passband of 300 kHz. The whistler spectrum was constructed by means of recirculation spectral analysis. This paper derives analytical expressions for the electron whistler magnetic bremsstrahlung in a magnetically active plasma and uses the above "Araks" data for a comparison of calculated and measured whistler spectra. The calculated spectra have a sharp maximum shifted in frequency from the frequency $f = f_{ce}/2$, where f_{ce} is the gyrofrequency of the electrons at the injection point. Sharp maxima are also observed in the spectra in the experiment at frequencies on the order of $f_{ce}/2$. The wave spectrum in the pauses between electron injection pulses cannot be explained within the framework of a linear emission mechanism, though this question is treated in other literature. The authors are grateful to A.A. Galeyev for his useful discussions.

Figures 2, references 6: 1 Russian, 5 Western.

[101-8225]

/8309

KOVTUNENKO ON PHOBOS MISSION PROFILE, NEW SPACECRAFT DESIGN

Moscow PRAVDA in Russian 20 Oct 86 p 7

[Article by V. Kovtunenko, corresponding member, USSR Academy of Sciences]

[Text] As already reported, in the Soviet Union preparations are being made for a new international space experiment which has been given the name "Phobos." The interplanetary automatic station developed within the framework of this project is to execute an expedition to Mars for implementation of a multipurpose task: investigations of the Martian satellite Phobos, Mars itself, space and the sun. The beginning of the expedition was planned for July 1988. The flight to Mars will require 200 days.

***

Recently the attention of space researchers has been directed increasingly to the so-called minor bodies of the solar system: comets, asteroids and planetary satellites. Data on these bodies will make it possible to draw aside still more the curtain hiding the secret of the origin of the universe. In combination with new information on the planets, scientists are obtaining an effective means for interpreting those pages in the earth's history which in the opinion of specialists cannot be read using only terrestrial material. And a knowledge of history is a preview of the future. Now highly interesting results of an encounter of space vehicles with Halley's comet have already been obtained. A still more extensive and saturated program is intended for investigating another representative of minor bodies -- Phobos.

Its study is the basic goal of the future experiment and the most complex from the point of view of technical realization. The present-day rate of development of space science requires from designers the fabrication of such "research instruments" which will make possible a considerable broadening of the scientific program of each new interplanetary expedition. The possibility of carrying out quite detailed investigations of considerable regions on the surface of the studied celestial bodies is especially important. The most critical stages in the scientific program must be carried out only in an automatic regime. A broad field for clever, and at times, also unexpected solutions, is afforded here.

For example, since the gravitational influence of Phobos is small, a fundamental possibility appears for carrying out repeated remote investigations of its

surface during slow movement of the terrestrial emissary at a given low altitude with periodic "hovering" for a more detailed analysis. But a flyby over an area with poorly studied relief is possible only by using on-board control systems which are capable of automatic evaluation of the situation and rapidly making appropriate "decisions." This new, exceedingly promising variant also serves as the basis for the considered project.

The "Phobos" spacecraft is the first representative of a new generation of Soviet scientific spacecraft capable of solving this class of problems. Recent advances in Soviet space technology have been concentrated in this vehicle. All systems in the vehicle are new and there is extensive use of computers capable of solving problems of a quite high "intellectual level."

Thus, the developers of the electronics system have provided on-board and service devices ensuring highly precise trajectory measurements, reception and processing of a great volume of service and scientific information. A control complex has been developed which includes a special on-board computer and precise sensing elements. Flight control algorithms and scientific apparatus have been developed for a comprehensive program for the exploration of Phobos. Miniaturized optical-electronic sensors have appeared, among which a so-called star-planet instrument, capable of sensing both an extremely "faint" star and an extremely "bright" planet, is included. The combined highly efficient and economical engines have made it possible to realize the highly energy-demanding scheme for flight to Phobos and also maneuvering of the station in orbit. New sources of power supply are capable of accumulating and then delivering a substantially greater quantity of power in comparison with those used earlier.

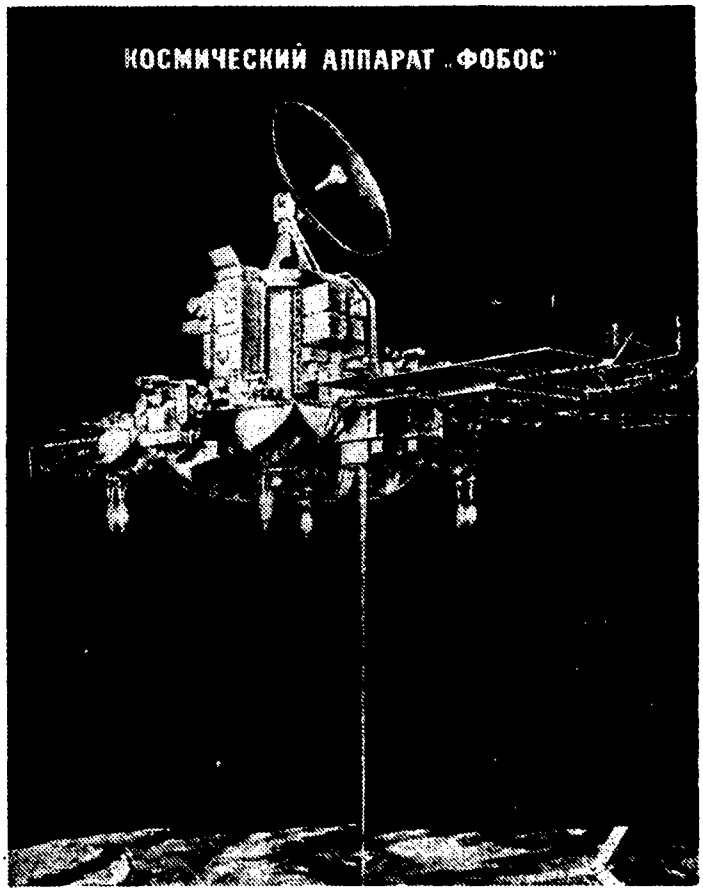
It is impossible to make an approach to Phobos immediately after arrival of the automatic interplanetary station in the neighborhood of the planet, so to speak, "in a rush." Our knowledge of the Martian satellite itself and about the trajectory of its motion are not yet adequately precise. Accordingly, "Phobos" first must become an artificial satellite of Mars and from a circular equatorial "observation orbit" whose altitude (about 6,330 km) is approximately 350 km greater than the orbit of Phobos it will make independent navigational measurements of the parameters of its motion relative to the studied object. At the same time a television image of Phobos will be transmitted to the earth in order to make its figure and relief details more precise. About a month will be devoted to this.

After the information has been processed by terrestrial computers, by commands from the earth a maneuver will be made for station transfer into an orbit synchronous with Phobos. The next two months will be allocated to the collection and processing of information enabling the station to be "led" a distance as close as 35 km to the studied object. Beginning from this altitude, but now by commands from on-board systems and instruments, it will be brought closer to Phobos.

At the "hovering" altitude (about 50 m) over a period of 15 minutes it is planned that comprehensive research will be carried out, including a television survey, radio probing of the internal structure of Phobos and laser and ion-ray

irradiation of its surface with evaporation of samples of matter for study of the chemical and physical properties of surface material aboard the station. Upon completion of the "hovering" segment a landing module will descend from the station and carry out a panoramic survey of Phobos.

Thereafter the spacecraft should first be "lifted" to an altitude of approximately 2 km, at which 20-m "whiskers," the antennas of the radar complex, will be deployed for studying the subsurface layers of the ground, and then, all also in an automatic regime, it will be withdrawn from Phobos to the stipulated orbit of an artificial satellite of Mars in order to continue implementation of the scientific tasks of the expedition. These include, for the first time, making surveys of the side of the sun which at the particular moment cannot be seen from the earth in the X-ray, UV and visible ranges; these will make it possible to warn in advance about processes transpiring on our sun, such as the generation of flares.



"Phobos" spacecraft.

Remote studies of the Martian surface and its atmosphere in the visible, UV, IR and gamma ranges from the orbit of its artificial satellite will constitute a continuation of the work initiated by Soviet and American space vehicles in the 1970's and at the same time will represent the beginning of a new stage.

In this stage the most important task is the detection of moistened regions on Mars which are best suited with respect to finding traces of life, future landing sites for vehicles of terrestrial origin.

In development of the new automatic interplanetary station provision was also made for the development of other stations capable of carrying out future scientific expeditions to planets, comets and asteroids.

In addition to the instrument compartment designed in the form of a torus, the main construction unit of the spacecraft, which houses the principal servosystems, was the second instrument compartment, designated for the electronic components of the scientific instrument package. The highly directional antenna is mobile relative to the body of the craft, making possible its orientation on the earth during its maneuvering near the surface of Phobos. Provision has been made for platforms for the apparatus to be carried to the studied surface (long-operating self-contained station and self-propelled vehicle) and a manipulator for moving the self-contained station beyond the limits of the spacecraft.

The servosystems will also include means for implementing the approach to Phobos.

Now the final stage in development of the "Phobos" automatic interplanetary station is beginning. Experimental checking of the vehicle as a whole and its systems is being carried out using mock-ups with simulation of the external conditions operative during the time of flight. Large groups of specialists having much experience in developing space apparatus are involved in the work. The results of these tests are confirming the correctness of the systems, design and technological decisions embodied in the project.

5303
CSO: 1866/15

MANAGADZE DESCRIBES PHOBOS LASER EXPERIMENT

Moscow LENINSKOYE ZNAMYA in Russian 14 Oct 86 p 4

[Article by Georgiy Managadze, Doctor of Physical-Mathematical Sciences, head of the laboratory of active experiments of the USSR Academy of Sciences' Institute of Space Research]

[Excerpt] Our institute is preparing to carry out unique experiments with the participation of scientists of other countries which belong to the "Intercosmos" organization. These experiments are part of the "Fobos" (Phobos) project which is planned for the middle of 1988. It calls for sending two spacecraft to Mars and its moons Phobos and Deimos.

We wish to know what kind of material Phobos consists of. The experiments must be conducted in such a way that the primeval condition of the surface of the planet's moon is not violated. A vehicle could not land on Phobos without leaving any traces: landing engines would contaminate its surface. This is the reason that our plans call for the soil [of the surface] to be studied while 'hovering' over the Martian moon for a period of 15 minutes. A laser will help us do this.

Scientists of six countries are cooperating with us in developing the instrumentation. Specifically, colleagues from the German Democratic Republic's Institute of Space Research are making optical components for the laser, and specialists from Czechoslovakia and Leningrad have developed a range-finding system and a special lens for steady focusing of the ray into a thin beam on the uneven surface of Phobos. Computers for onboard processing of the information, which must summarize the results of the studies, were made in the Federal Republic of Germany.

The experiment using a laser in the "Fobos" project is called "Lima-D." Apparatus which is a prototype of that which will fly in space exists in laboratories. It operates in the following manner: the laser beam vaporizes the substance of a soil specimen, creating tiny charged particles--ions,

and then with the aid of a special accelerator, which is a kind of 'vacuum cleaner,' these ions are drawn into a chamber where their mass spectrum is determined, from which conclusions about the substance's composition can be made.

Laboratory experiments are one thing, but working in space is quite another. We can't take this 'vacuum cleaner' to Phobos. We have come up with the idea of studying ions which are flying around without an accelerator, in free flight. We have thought out the technique of the whole experiment. With sufficient laser power, the particles that are formed by vaporization can rise from the planet's moon to a rather high altitude. The spacecraft, hovering approximately 50 meters above the surface, will capture them in a 'trap,' and instruments will determine the mass spectrum of the particles and send the data to Earth.

We plan to take about 150 shots at the surface of Phobos with this peaceful laser.

FTD/SNAP
/8309
CSO: 1866/45

INTERPLANETARY SCIENCES

COMMENTS ON PHOBOS PROJECT, USE OF RT-70 ANTENNA

Moscow SOVETSKAYA ROSSIYA in Russian 24 Sep 86 p 6

[Article by L. Valentinova: "Project 'Phobos'"

[Text] "Forward, to Mars!", in this passionate slogan of Fredrik Tsander the dreams and aspirations of many generations are embodied. Let us recall the feverish excitement of the entire civilized world in past ages when canals were discovered on the "red planet," which were taken to be irrigation systems of Martians perishing from thirst. Perhaps this was the only time when an astronomical problem was colored by purely human emotions.

Our neighbor Mars has long excited the human intellect. It has been considered the most realistic island where there exists or could have existed life in the solar system. It is no accident that Mars was the setting in the novels of Alexey Tolstoy, Bradbury and Lem. In our day the possibilities of science and space technology allow not only to dream about travel among the stars but to do it.

The first spacecraft from Earth to be sent toward Mars was "Mars-1" launched in the Soviet Union in 1962. With this flight a new chapter was opened in the study of the planet, the space chapter. Since that time six more Soviet space stations have been sent to Mars, and several times descent modules have landed on the surface of the red planet. The American series of automated space stations, "Mariner" and "Viking" have flown to Mars. And it must be recognized that thanks to the automated stations we now know much about our neighbor. The temperature and pressure have been measured, the composition of the atmosphere analyzed, the relief photographed, and a quite good map has been compiled. But much is unknown.

It would seem that nothing could be simpler. Create space stations, send them near to the object of interest, and let sensitive instruments acquire the needed information. It is easy to say this. But how can this be done? The orbits of the heavenly bodies must be known with high precision, and it is necessary not only to calculate the flight trajectory of the spacecraft, but to be able to direct it from Earth so that it can follow all the planned maneuvers without a hitch.

This most complex problem was brilliantly solved by Soviet scientists during the recent "Vega" project, when automatic stations on the way to Halley's Comet confidently performed maneuvers in space aerobatics. Communication with the stations was maintained through a unique system, including the RT-70 antenna. Very soon it will take a most active part in the amazing Mars expedition.

The hit Crimean sun scorches all the plant life in these parts. And it presses close to the huge antenna, there is no other shade to be found in the area. The climate is certainly not very suitable for working. But the location has an advantage. Radio operators know that near the sea radio waves propagate better. It was even initially proposed to build the RT-70 on an alluvial island.

The antenna makes a surprising impression. Its total height is 85 meters. The mirror system is made of duralumin and weighs 1,700 tons, but the precision of fitting the metal sheets is up to one millimeter. The dish of the antenna is 70 meters in diameter and reminds one of a cycle track, rising on the roof of a 16 story building. The RT-70 freely and even elegantly rotates to any angle with a precision incomprehensible for such a bulky and cumbersome thing.

Together with the chief engineer Oleg Petrovich Zverev we examined the facility, which is full of countless mechanisms and instruments. More than 20 technical solutions are protected by author's certificates. And I never ceased to be surprised that with the grandiose size of the RT-70 it gave the impression of being light and graceful.

The RT-70 antenna worked excellently during the Venus-Halley program. Now there is a new, still more complex problem. In the summer of 1988, it is planned to launch two spacecraft from the Baykonur cosmodrome a few days apart to investigate Mars and its satellites. The date of the launching is selected with consideration of minimum use of fuel during the flight. Nonetheless, the distant goal of the spacecraft will be attained only after 200 days travel, and the entire expedition is designed for 460 days. In the international project "Phobos" there will be participation by scientists and specialists from socialist countries, Austria, FRG, France, Sweden and the European Space Agency.

The deputy director of the Institute for Space Studies of the USSR Academy of Sciences, V.M. Balebanov said: "Two automatic stations using special instruments will subject the surface of Mars to careful study, its atmosphere, ionosphere and magnetosphere. In January 1989 there will be acquisition of television images of the planet and detailed data on the chemical and mineralogical composition of the rocks, and their radiophysical characteristics and a thermal map will be made. Apparently it will be possible, at last, to understand the mechanism causing dust storms on Mars. And after this both

stations, using complex maneuvers, will move to the elliptical orbit of Phobos. The Earth envoys will approach to within 30 to 50 meters and conduct investigations during a "grazing" flight. And in April 1989 the most interesting thing will occur. Long-term automatic stations will be landed on Phobos, which will start direct reporting from its surface. The satellite will be illuminated with long wavelength radiation, by lasers and ion beams. Such powerful 'X-raying' will permit determining the elemental and isotopic composition of the enigmatic Phobos soil."

It is appropriate to ask why are the scientists so interested in Phobos, the undistinguished satellite of Mars with a diameter of only a few kilometers? Phobos (from the Latin for "fear") is one of the most agonizing riddles for astronomers. How can its strange orbit around Mars be explained? The well-known Soviet astrophysicist and corresponding member of the USSR Academy of Sciences I. Shklovskiy put forth a rather well argued hypothesis according to which Phobos is an artificial object. Indeed, all calculations show that only a hollow body could move in such a manner. But photographs obtained by spacecraft have showed that Phobos, and the second satellite Deimos ("Terror") are natural objects. They are large shapeless blocks with notable craters. In addition, Phobos is covered with multiple parallel furrows. From all appearances the satellites of Mars belong to the type of asteroids that are primary objects of the solar system. But all this is still just hypothesis. As before, the questions to be answered include the origin of the satellites, their age, structure and composition. The answer may simultaneously elucidate the riddle of the origin of the solar system.

The RT-70 is not only an antenna, transmitter and receiver, but a complex of unique instruments, mechanisms and computers. For 5 to 6 hours, the length of a session with the "Vega" spacecraft, 600 commands were transmitted from here in the automatic digital mode.

However, said O. Zverev, for the Phobos project such precision is not enough. The apparatus installed on the antenna will be practically totally replaced. More powerful transmitters, more useful frequency bands for radio communications, and the fastest computers will be used. There is a great deal of work to do. Indeed, the time left before the start of "Phobos" is nothing at all in astronomical terms.

13144/8309
CSO: 1866/12

SPACECRAFT DATA AID IN DESCRIBING VENUS'S GEOLOGY

Moscow PRIRODA in Russian No 6, June 86 pp 24-35

[Article by Valeriy Leonidovich Barsukov, corresponding member of AN SSSR [USSR Academy of Sciences], Director of the AN SSSR Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy and Vice President of the International Union of Geological Scientists; and Aleksandr Tikhonovich Bazilevskiy, Candidate of Geologico-Mineralogical Sciences and Manager of the Laboratory of Comparative Planetology and Meteoritics of the same institute: "The Geology of Venus"]

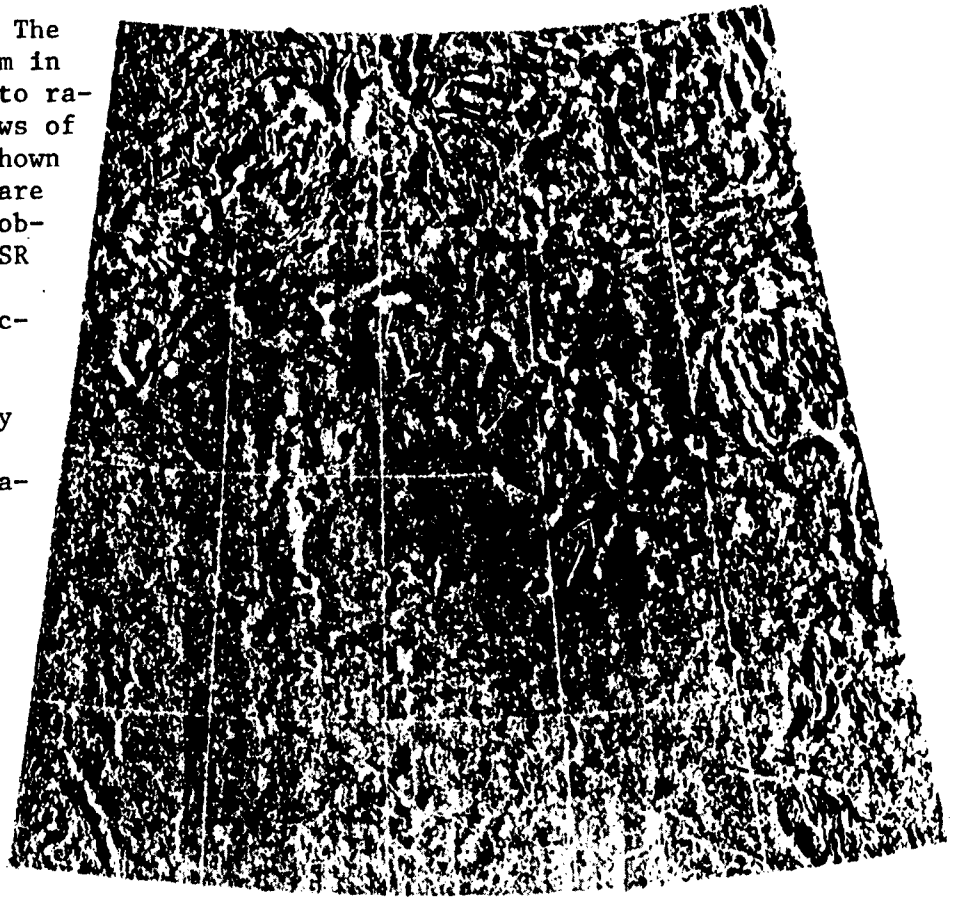
[Text] Although geologists, just like other earthdwellers, still have not visited Venus, today it no longer causes astonishment that one can get a notion not only about the surface but also about the composition of this planet's rocks and the processes that are going on in its interior. In other words, a branch of natural history is taking shape which we, from earthly habit, call the geology of Venus.

Astronomers have been studying Venus for several hundred years, and in our day it has become the object of intense study by means of spacecraft. The cause of the tireless attention to Venus is not only its proximity to Earth but also the similarities of its weight and size, and that means also of the average density of its substance, and, probably, of the chemical content to the Earth's. If one recalls that back in the 18th Century M. V. Lomonosov discovered the atmosphere of this planet and, as a consequence, found that Venus had a cloud cover, then it becomes clear why it is that Venus is often called the Earth's sister. It seemed not so long ago that everything on Venus should be like what exists on Earth: the surface, geological processes and geological development, and, even, as some hoped, a history of an origin and evolution of life. However, during the past 20 years, it has become clear that conditions on the surface differ sharply from the Earth's: the surface temperature is close to 500 degrees C, the atmospheric pressure is about 100 atmospheres, and the atmosphere is not oxygen and nitrogen, as it is on Earth, but is basically carbon dioxide, and the clouds are not made up of water droplets but of drops of concentrated sulfuric acid. It has become clear at least that one does not speak about life on the surface of Venus. The mechanism of heating of the atmosphere and of the surface of Venus also has become clear--it is the greenhouse effect, which is connected with the fact that the carbon dioxide admits the solar rays that heat it but hinders the return flow of the heat radiation. But when did

Valeriy Leonidovich Barsukov, Corresponding Member of the AN SSSR [USSR Academy of Sciences], Director of the AN SSSR Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy and Vice-President of the International Union of Geological Sciences. A specialist in the area of space chemistry, the geochemistry of the oceans, and the geology and geochemistry of ore deposits. Winner of the USSR State Prize. He has published repeatedly in PRIRODA.

Aleksandr Tikhonovich Bazilevskiy, Candidate of Geologico-Mineralogical Sciences and Manager of the Laboratory of Comparative Planetology and Meteoritics of the same institute. He is occupied with planetology and geochemistry. He has published these articles in PRIRODA: "Stages of Comparative Planetology" (1977, No 3); and "Meteorite Craters" (in co-authorship with B. A. Ivanov, 1985, No 10).

The Plain of Sedna. The area is 1500x1500 km in size. Arrows point to radio-bright lava flows of capricious shape. Shown here and elsewhere are portions of images obtained by the AN SSSR Institute of Radio-Engineering and Electronics while processing the results of radar photography obtained from the Venera-15 and Venera-16 spacecraft.



the greenhouse effect start operating on Venus, and were the planet's conditions always so different from those of the Earth? Did there ever exist on Venus a moist and warm kingdom of treelike ferns and reptiles that is described colorfully in science fiction? The answers to these questions lie in the geological record of Venus.

But Venus's geology is interesting not only from the point of view of the past and future of this planet. It can shed light also on the Earth's evolution. As a planet, Venus is simultaneously similar to the Earth in some parameters and sharply different in others and is an important link in comparative planetological analysis.

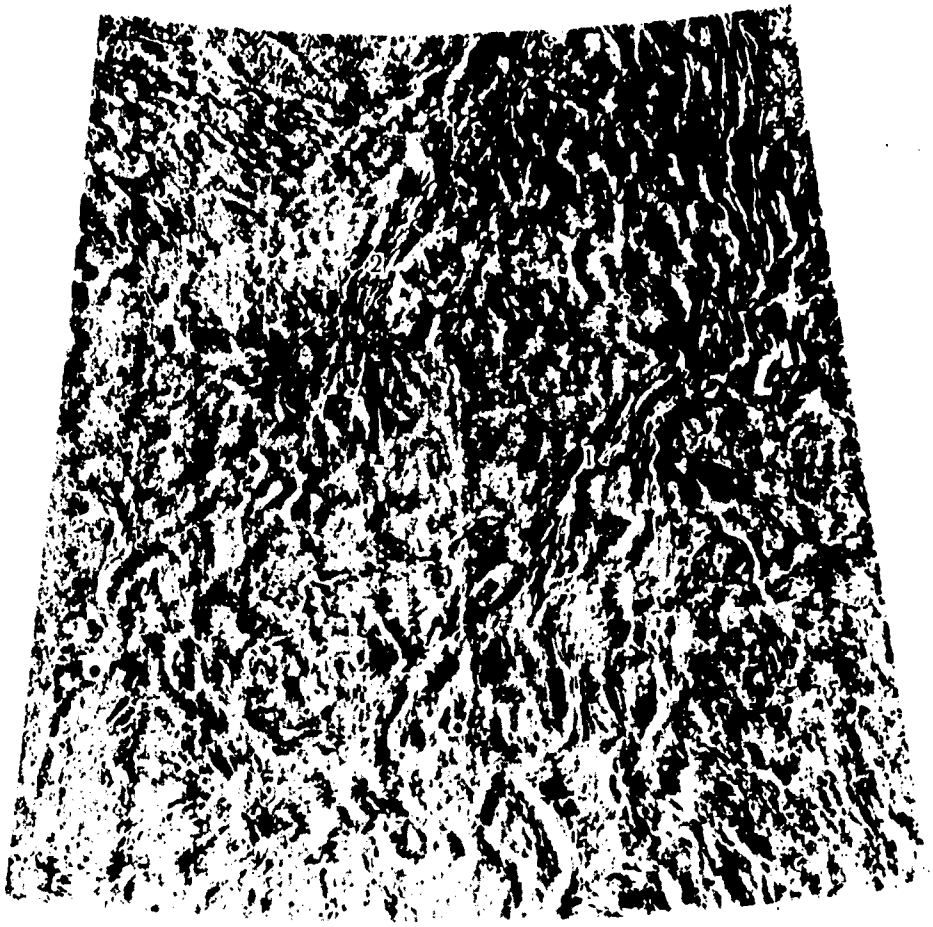
And so we must develop a notion about the geological structure of Venus. But how to do this when it is doubtful that it will ever be possible to do geological research on Venus in the traditional sense because of the severe conditions on its surface? The path of geologico-morphological analysis remains, that is, analysis of the nature of the relief (the morphology), by which one can draw conclusions about the geological structure of a locality. For example, in photographs taken from altitude, one can unmistakably recognize volcanic structures and lava flows, fields of sand dunes, river valleys and tectonic fractures. With less confidence, one can single out sedimentary rocks (they resemble layers of volcanic ash) and certain other shapes. Suffice it to say that geologists also resort to the morphological method ever more frequently now even on Earth, making up a preliminary geological map from photographs taken from space and from aerial photography, which is then verified and refined on site. Geologico-morphological research was successfully applied in the study of planets for the first time during study of the Moon.

Photographs of Venus's Surface

By the end of the 1970's the Americans had succeeded, with Earth-based radar, in obtaining an image of a small portion of the surface of Venus, in which objects several tens of kilometers in length were distinguished. However, photographs of almost the planet's whole surface (except for its polar regions) by the American spacecraft Pioneer-Venus gave the first overall notion about Venus's relief. With its help, it became possible to establish that plains predominate on the surface of Venus, and their level is close to the average value for the radius of this planet. The hypothesis was expressed that at least a portion of the plains are volcanic in nature. Observed in addition to them were two vast mountainous areas the size of Earth's Africa and Australia put together, which rose above the plains by an average of 4-5 km; these were called, respectively, the Land of Aphrodite and the Land of Ishtar. The nature of these elevations remained unknown at the time. Certain elevations of smaller size (for example, the Beta area) were ascribed to volcanic formations.

Photographs from the Soviet automatic spacecraft Venera-15 and Venera-16, which were sent to Venus in 1983, enabled a more reliable geological interpretation to be made. They became artificial satellites of Venus and for 8 months they conducted radar photography of its Northern Hemisphere, north of Latitude 30°. This embraced about 115 million km^2, or one-fourth of the planet's whole surface. The photographing apparatus included a side-looking radar, in which objects 1-2 km in length could be pictured, a radio

Landscape of the Venera-13 Landing Site. A portion of a television-photo panorama. The distance between the cogs on the lander's ring support is 5 cm. Dark broken-up soil and fragments of layered rocks that have emerged onto the surface are seen.



Belts of Ridges (1) and Stria (2) on the Surface of the Plain of Beregina. The area is 1500x1500 km in size. To the southwest the ridges are changed by odd "parquet-shaped" structures, probably of volcanic-tectonic origin.

altimeter with 50-meter precision for determining the average altitude at a "spot" 40-50 km in diameter, and a radiometer that recorded Venus's own radiowave radiation.

A set of on-board instruments and special Earth-based equipment for processing the information obtained were created as a result of the creative collaboration of groups from the AN SSSR Institute of Radio-Engineering and Electronics and the Moscow Power-Engineering Institute. A working group that included staff workers of the AN SSSR Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy, the AN USSR Geological Institute, and the AN SSSR Institute of Earth Physics imeni O. Yu. Shmidt, was created in order to make a geologico-structural and geochemical interpretation of the data obtained. The results of this research have already been published and they continue to be published in the science press. In this article we are trying to give a popular exposition of certain more interesting results.

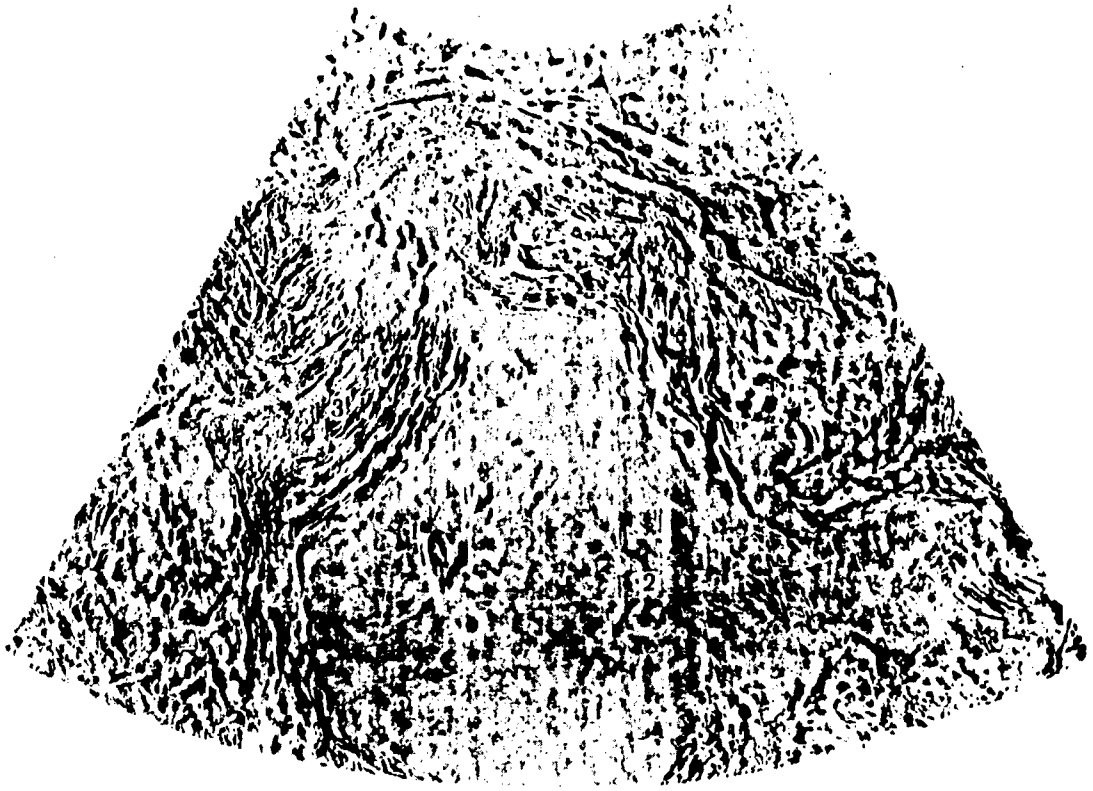
The orbits from which the photography was accomplished were close to polar, with an orbital period of about 24 hours and with a pericenter (the orbital point closest to the surface) location of about 62° N. Latitude. During the photography the altimeter "looked" below vertically and the side-looking radar looked at 10° to the right of the orbital path. Photography during each operating lap of the orbit started in the area of the planet's North Pole and continued south to 30-35° North Latitude. During each such pass a strip of radar images was obtained on a scale of 1:4,000,000 with a width at the site of about 160 km and a length of 7,000-8,000 km. During the first stage of processing the strip, the images were joined together into a mosaic manually, and then by means of a computer.

The Land of Ishtar, with the highest mountains on Venus, the Maxwells, a number of elevations of lesser size, including the Beta area mentioned above, and a number of plains areas, including the lowest one on Venus, the Atalanta Plain, were completely included in the zone photographed. During analysis of the images obtained, it turned out that plains predominate in the area photographed, as it does for Venus as a whole. As a rule, their level was close to the average level of the planet's surface, or somewhat below it. Only the Lakshmi Plateau, to the west of the Land of Ishtar, was uplifted 3-4 km above the planet's average level.

The Plains

Elongated (up to 200-300 km long) "radar-bright" formations--that is, more luminous radar images--that are reminiscent of basaltic-lava flows on the Earth, Moon and Mars, were often seen on the surface of the plains. Sometimes they start from rounded depressions of the volcano-crater type and calderas or from a fracture. There is no doubt that these shapes are congealed basaltic-lava flows. Their greater radar brightness is associated with the high degree of roughness of their surface, which is typical for most fresh lavas. But actual measurements on the landers of the automatic spacecraft Venera-10 and Venera-14 and Vega-1 and Vega-2, which landed on Venus's plains, outside the zone photographed, showed that in these places the surface rocks of the plains are close in chemical content to the Earth's basic magmatic rocks of normal alkalinity--gabbros or basalts. Probably, lava of basaltic composition is the chief material out of which the plains on Venus

The Crown of Anakhit, about 400 km in Diameter, on the Snowmaiden Plain (1). On the right of the Crown of Anakhit are radio-bright lava flows (2), to the left is the Valbor impact crater (3), about 20 km in diameter. In the left portion of the photograph is the Crown of Bachue (4), partially covered by lava.



The Lakshmi Plateau and Its Mountain Framework. The area is 2000x2000 km in size.

1. The Colette caldera.
2. The Sacagawea caldera.
3. The Akhna Mountains.
4. The Frey Mountains.

were formed, although perhaps aeolian deposits of volcanic ash or sand-and-dust products from the destruction of previously formed rocks, can play a certain role here. We see such finely clastic material on the television panoramas of the landing-site localities of the spacecraft Venera-9, Venera-10, Venera-13 and Venera-14, at times in the form of loose dark soil, at times in the form of horizontally layered porous rocks.

The rocks of Venus's plains do not always correspond in composition to ordinary earthly basalts. At the landing sites of Venera-8 and Venera-13, on the plains of Venus (outside the bounds of the radar photograph), the surface material is reminiscent of fairly sparse alkaline rocks of the Earth--alkaline basaltoids or syenites. It still is not clear which geological formations are made up of this substance.

Sometimes "small" dome-shaped hills several kilometers in diameter, often with a crater at the summit, and also elongated belts of ridges and furrows several thousand kilometers long and up to 100-200 km wide, are sometimes encountered on the surface of the plains.

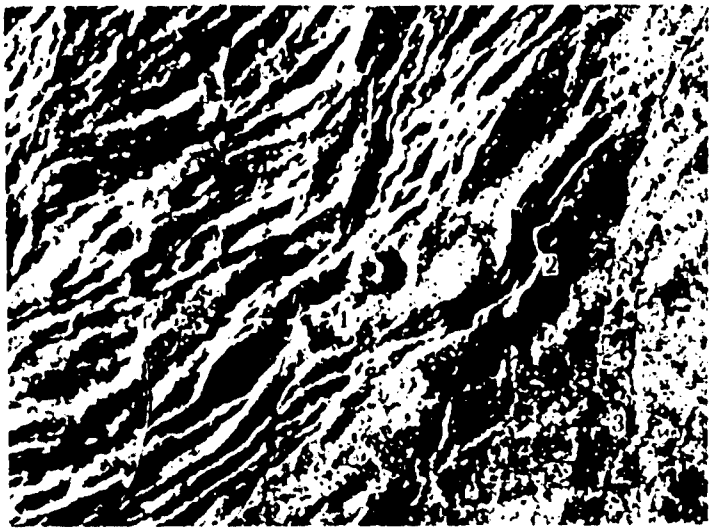
At the plains around the Land of Ishtar, so many unusual ringlike formations were observed that they have not been named in the planetary-nomenclature system. They have been given the term "crowns." Venus's crowns are similar in their structural appearance to tectonic structures of oval shape which are characteristic for areas of development of the Earth's most ancient rocks. Each crown has been formed by a concentric-ring system of mountain ridges, within which an area of "chaotic" relief is located. These structures are enormous in size--from 200 to 600 km in diameter. Systems of "radar bright" lava flows are often visible on the surface of the plains around the crowns. These structures evidently were formed above sections where materials were raised up from Venus's interior. This material was hotter than the material in the neighboring sections, causing deformations of the rocks which emerged on the surface and volcanic eruptions. It is not excluded that these hot sections were formed at one time by the impacts of very large meteors.

The Mountains

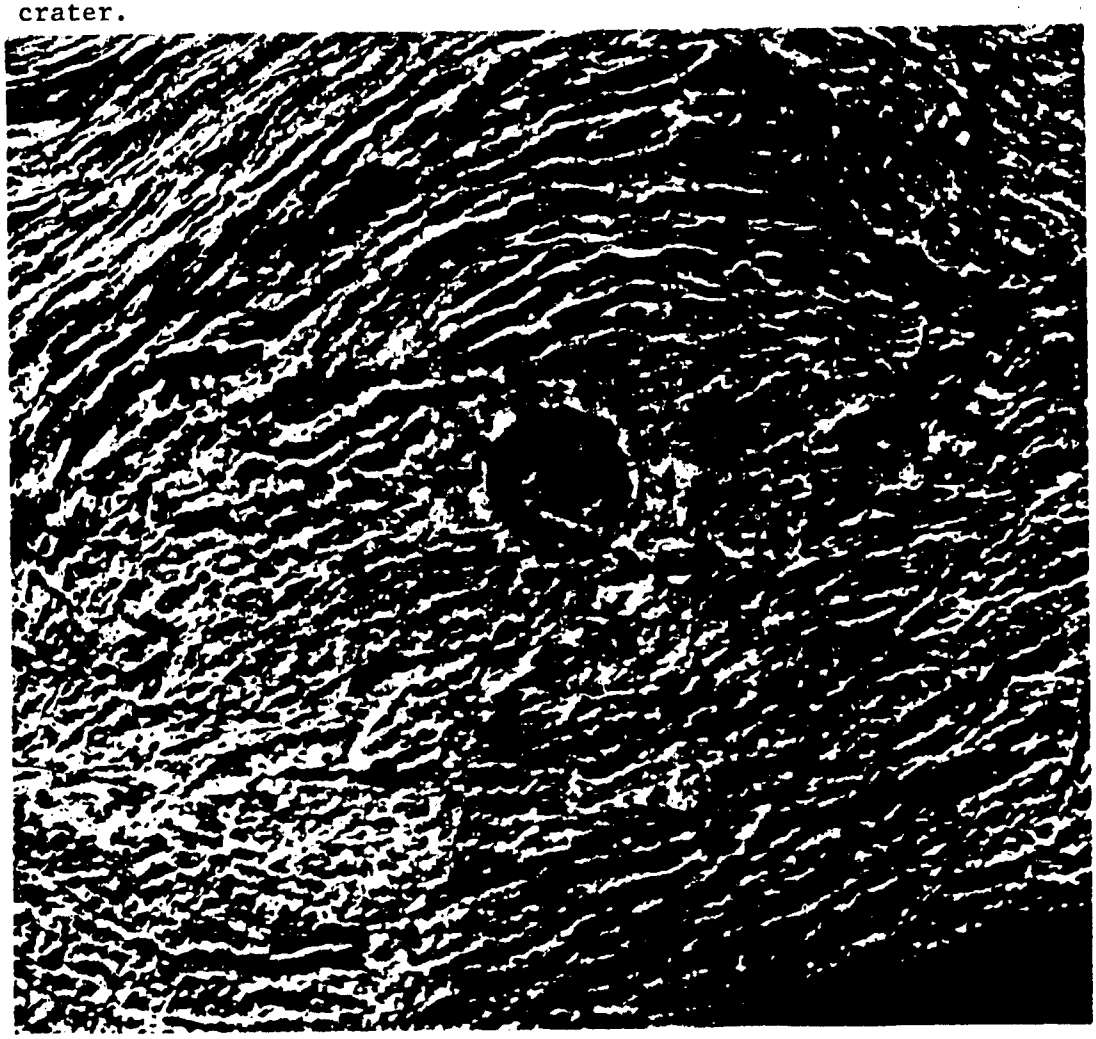
The mountains in the areas photographed by Venera-15 and Venera-16 were primarily a mountain system of the Land of Ishtar. It is 7,000 km long from west to east and 3,000 km from north to south. The Lakshmi Plateau is located in the western part of the Land of Ishtar. Two large oval depressions--the Colette (80x120 km) and the Sacagawea (100x200 km), which are reminiscent of certain Martian volcanic calderas--were singled out on its surface, which is elevated above the Sedna plain, which is adjacent on the south. Around the Colette depression, which apparently was formed earlier than the Sacagawea, a system of radially divergent radar-bright lava flows is seen. Probably the latter are traces of the once-powerful volcanic activity that formed the surface of the Lakshmi Plateau.

The Lakshmi Plateau is surrounded on almost all sides by mountain-range systems and the valleys that separate them, valleys which are parallel to the plateau's boundaries. These are the Akhna Mountains on the west, the Frey Mountains on the north, the Maxwell Mountains on the east, and the Vesta bench to the south. Judging by the relief, these mountain ranges rose

[Left] Asymmetric Mountains of the Akhna Mountain Range. The area is 400x500 km in size. Two impact craters are visible, one of which breaks up the system of mountain ranges (1) and, thus, is younger than they are; another (2) borders the Akhna Mountains and the Lakshmi Plateau (3) and is cut by the Akhna Mountain Range, and, so, is more ancient than they are.



[Below] The Maxwell Mountains. The area is 750x750 km in size. The long parallel mountain ranges of the Lakshmi Plateau's framework are shifted by short broken lateral displacements with mountain ranges of the parquet-type locality. In the center is the Cleopatra Crater and portions of the smoothed area around it, apparently made by discharges from this crater.



up during crumpling of the surface rocks into folds or the overthrusting thereof in the form of plates that were split off from each other. In any of these cases, compression in a horizontal direction is required for the formation of mountains, which is characteristic for mountainforming processes on the Earth but not typical for either the Moon or Mars. The causes of these tectonic deformations under the influence of horizontally disposed stresses are still be to be established.

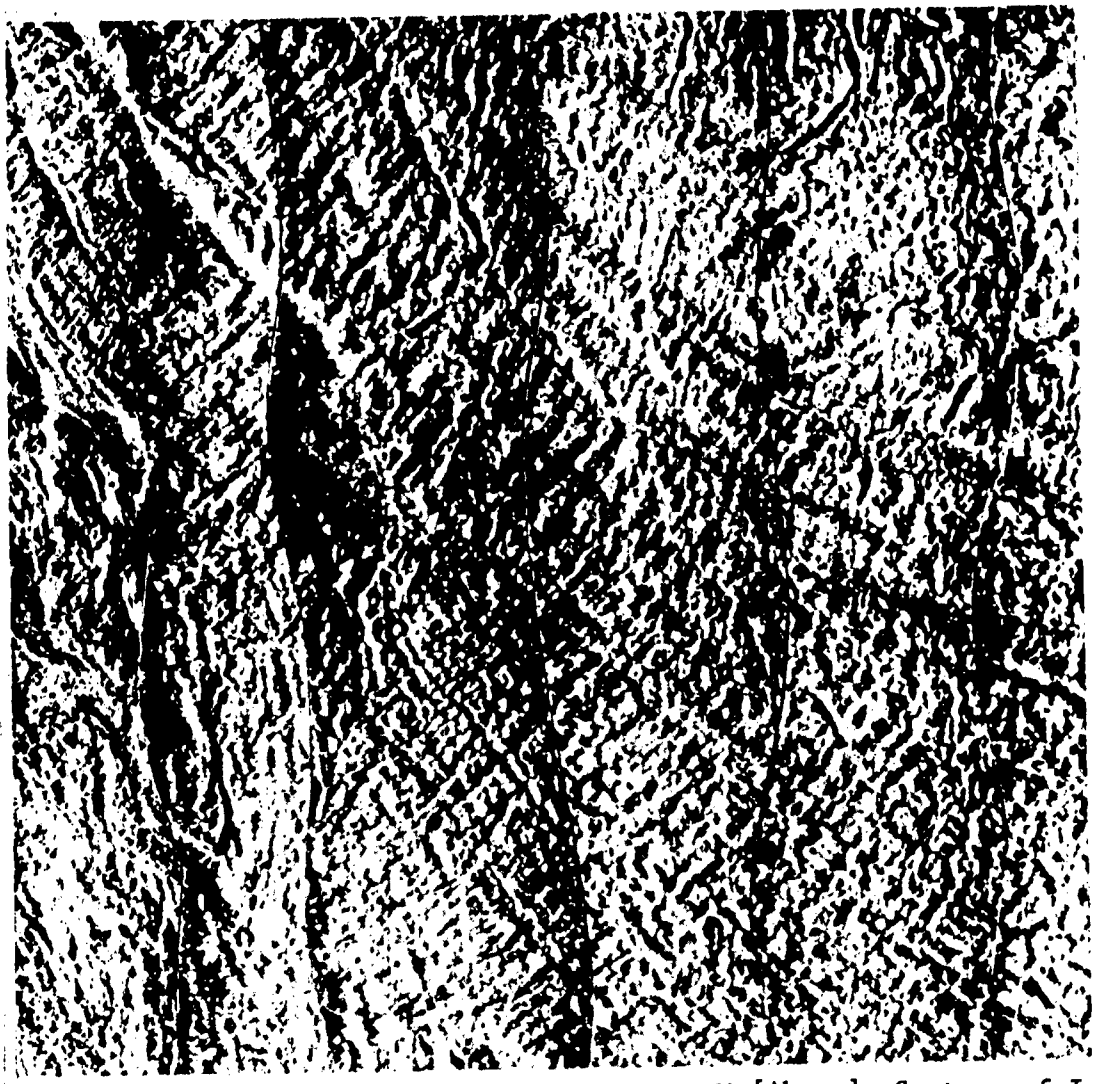
The Lakshmi Plateau and its mountain framework form an aggregate like a gigantic crown, and one can suppose that it also was formed through uplifts of the hot mantle material, except that the material here is much greater in scale than during the forming of "normal" size crowns. However, this is still only one of the hypotheses. Other possible causes also are being discussed. For example, deformations that rise into the planet's lithosphere with changes of the position of its axis of rotation and of its speed of rotation. The latter, as is known, is clearly an anomaly on Venus--Venus rotates around its own axis very slowly--each 243 earthly days--and in a direction the reverse of all the other planets.

In the mountains surrounding the Lakshmi Plateau, a gradual and sometimes even a sharp shift occurs in the type of terrain as distance from the plateau increases. Long mountain ranges and valleys parallel to each other and to the plateau's borders change the system of the shorter intersecting mountain ranges and valleys with a diagonal or random structural picture. A region of this type is not characteristic for other planetary bodies that have been studied. It has received the provisional designation "parquet," but it is "tessara" in the planetary nomenclature system, which means "tiled" in Greek. Something similar is observed only in the western part of the Farsid uplift on Mars. On Venus the "parquet" makes up only the eastern part of the Land of Ishtar, occupying an area of more than 5 million km^2, and a number of other elevations. In the southern part of the Land of Ishtar, there is an area where the surface relief has been formed by systems of intersecting mountain ranges and valleys. Here the structural picture reminds one of an area of stretching in the axial portion of the mid-ocean mountain ranges on the Earth.

It is obvious that both the "parquet" and the mountains that frame the Lakshmi Plateau rose up during a fracture of the surface rocks, where the stresses are horizontal in direction. In some cases this apparently is compresion in a horizonal direction, and in the other a horizontal stretching.

The "parquet" in the zone of Venera-15 and Venera-16 photography overlays there not only large elevations but also comparatively small sections that are partially "inundated" from the edges with material of the plains. At one time, evidently, areas of this type were distributed much more widely than today. It still is not clear how many of these relief forms are outside the photographed area. It is obvious only that they are characteristic for low elevations, and perhaps Venus's second largest elevation--the Land of Aphrodite--will also prove to be covered with "parquet."

Incidentally, the data of Venera-15 and Venera-16 indicate that large uplifts whose surfaces have almost a plainslike face are rising up among the plains of Venus. These are the areas of Betak, Bell, Ulfrun and Metidy, 2-4 km in



[Above] Systems of Intersecting Mountain Ranges and Valleys of the Layma "Tessara." The area is 500x600 km in size.

[Left] Impact Crater Cotton, 52 km in Diameter, with Radio-Bright Zones of Discharges.

altitude above the mean elevation of Venus. But here also, against a background of plains, one can see systems of parallel and fan-shaped diverging benches or very large volcanic mountains with a crater or caldera at the summit. The structure of these elevations is reminiscent of certain arched uplifts on Earth, with rift zones of depressions on their summits, which indicates a crust-stretching situation.

Craters

Amid the multitude of structures unknown to us that are in the Venera-15 and Venera-16 photography, impact craters from 4 to 140 km diameter, which reach 150 in number in the area photographed, are recognized fairly easily.

In planetology, the age of some structure is often determined by the number of craters on the surface. If, for example, it is known that over an area of 1 million km^2 two craters were formed in 1 million years, and 200 craters are observed on one section of such an area, then that means that the age of the surface here is 100 million years. According to "crater" assessments, the average age of the whole area of Venus covered by the photography is on the order of 1 billion years, just like the ages of this planet's plains. Let us note that they are much younger than the "sea" basalt plains of the Moon, which are 3 billion years old, but are older than the basaltic plains of the bed of the Earth's oceans. Mountainous areas with complicated relief also have an age of about 1 billion years, but impact craters were not observed on the elevations of Beta, Bell, Ulfrun and Metidy, a fact that evidently testifies to their relative youthfulness.

Among 150 craters of Venus, about 100 have brightly reflected morphological features--a hill in the center, steep slopes, a blowout zone, and so on. It is obvious that they were destroyed but little during the last billion years of the planet's geological history. Such a slow pace of destruction of craters is not characteristic for the Earth but it is for the Moon.

In addition to the obvious impact and volcanic craters, circular structures similar to them and from 16 to 200 km in diameter whose morphology is not clearly defined are observed on Venus. They are characteristic for various types of areas, but they still have been studied only in the plains. Some of these structures are probably badly demolished ancient impact craters with an age on the order of 3 billion years. For transforming "fresh" impact craters into such structures, those rates of reworking of the surface that are characteristic for the newest period of Venerean history clearly are inadequate. Obviously, during a period of the planet's history, from 3 to 1 billion years ago, the destruction of craters on Venus occurred somewhat more rapidly than it did later, but still not as rapidly as on the Earth.

Some quantitative evaluations of the pace of the "reworking" of the surface were made in terms of the preservation of various elements of the craters. It turned out that during the past 1 billion years, a layer of no more than several tens of meters were destroyed on Venus, but during the period from 3 to 1 billion years ago, no more than several hundred meters. Destruction of the surface on small planetary bodies of the Moon or Mercury type is occurring at approximately the same rate. But such low rates are not

Systems of Ledges at the Arched Uplift of the Beta Area, Which Testify to a Stretching of Venus's Crust. The area is 700x800 km in size.

The Two-Ring Impact Klenov Basin, 140 km in Diameter, in the Loukha Plain. The system of radio-bright ridges or belts around the crater that are typical for this region disappears, overlapped by discharges from the crater.

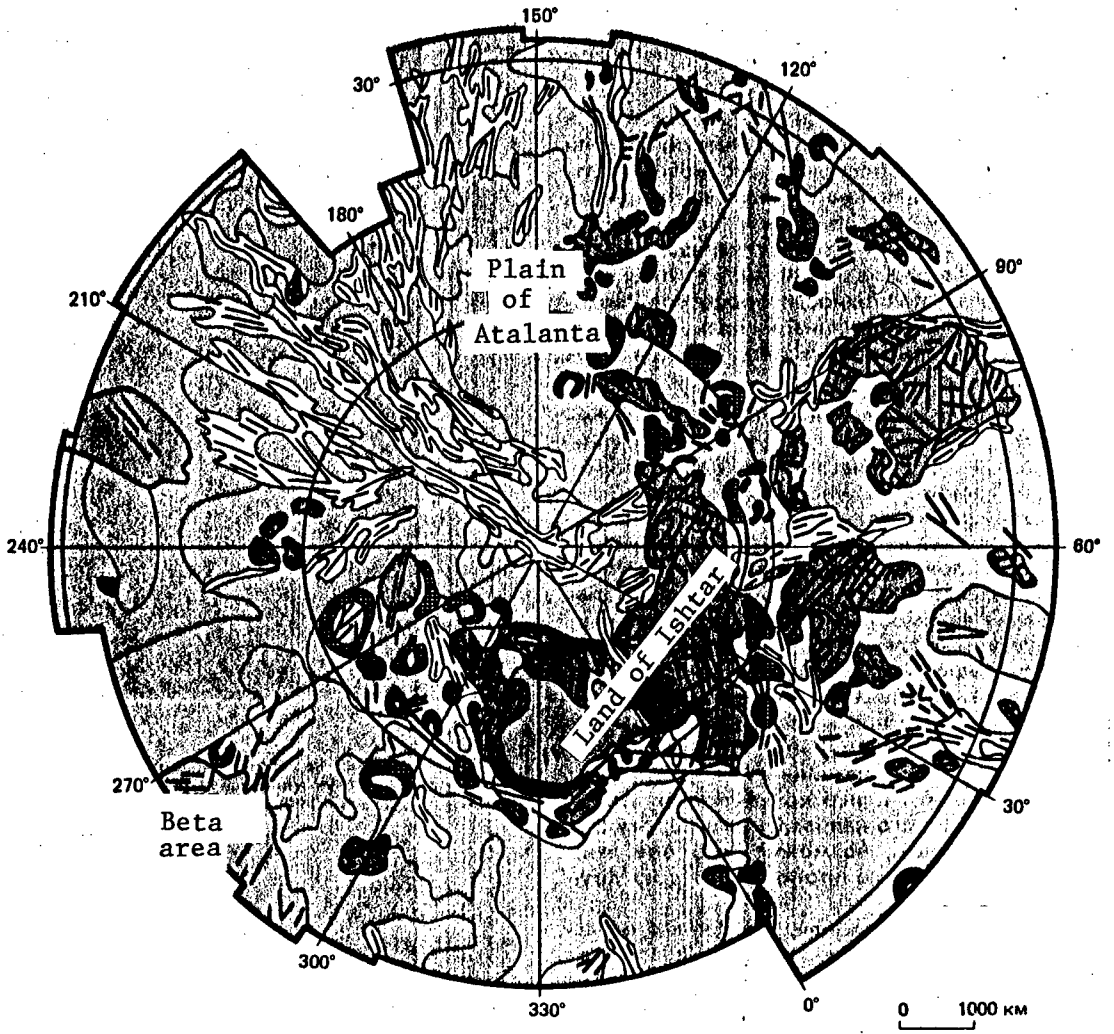
compatible with conditions similar to those on Earth, especially with the presence of the liquid water on the surface. Thus, the results of an analysis of Venera-15 and Venera-16 images indicate that at least during the last 3 billion years (and this is two-thirds of the "life" of the solar system's planets) a scorching lifeless wasteland, under the dense cover of a carbon dioxide atmosphere, dominates the Venerean surface.

The Geological Map of Venus

As the result of an analysis of Venera-15 and Venera-16 radar images, the Working Group created a geologico-morphological map of the photographed zone on a scale of 1:10,000,000, a simplified variant of which we present.

The first thing that catches the eye on the map is the predominance of volcanic plains above mountain areas. This is a new confirmation of conclusions previous drawn on the basis of a study of the Moon, Mercury and Mars that basaltic volcanism--the appearance on the surface of processes that differentiate material from the planet's interior geochemically--is a universal phenomenon for planets of the Earth group, and that the larger the planet, the stronger this phenomenon.

A certain orderliness is seen in the distribution of mountains areas formed by intense tectonic deformation in the area photographed. The area of the



Geologico-Morphological Map of Zones of Venus Photographed by Venera-15 and Venera-16 Spacecraft. Compiled by staff workers of the AN SSSR Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy and the AN SSSR Geological Institute.

- Hilly plains.
- Smooth plains.
- The Lakshmi Plateau.
- Mountain framing of the Lakshmi Plateau.
- Strips of ridges on a plain.
- Area of intersection of mountain ranges and plains (the "parquet").
- Elevations with slightly broken-up relief.
- Crowns
- Main structural lines.

strips of tectonic ridges of the Atalanta Plain appear as if they are opposing the zone of tectonic deformation of the Land of Ishtar, which is framed by crowns. Apparently all these formations are mutually connected. The direction of the stresses that occasioned them can be reconstructed by the arrangement of the structural elements in the zones of tectonic deformation. It turned out that in most cases it is close to a latitude that possibly testifies to a change in the rate of rotation of Venus or to convective "flows" of latitudinal direction below the Venerian surface. Then again, it is possible that these two hypotheses do not contradict each other.

We have already said that the data about the distribution of impact craters allows one to consider that the forming of most of the plains and mountains that are observed was completed 1 billion years ago or more, but only at the volcano-tectonic uplifts of the Beta, Bell, Ulfrun and Metidy areas and certain parts of the plains areas did younger volcanic or tectonic activity appear. These areas do not occupy a substantial portion of the map, so, basically, volcanic and tectonic activity died out long ago over most of the territory photographed. On the Earth, areas of the development of basaltic discharges and intense tectonic deformations less than 1 billion years in age sharply predominate for areas above the more ancient formations. It should follow from this that in the last billion years at least, the volcanic and tectonic activity on the Earth has been much stronger than on Venus. Possibly the cause of this is the greater activeness of the Venerean interior during the early stages of its development than was the case on Earth.

The Data of Vega-1 and Vega-2

While the results of the radar photography by Venera-15 and Venera-16 were being analyzed, new data from Venus appeared. The landers of the Soviet Vega-1 and Vega-2 interplanetary stations reached this planet and transmitted new information about the properties of its atmosphere and its surface. Here we shall dwell briefly on the results of determination of the chemical composition of the surface rocks at the landing sites, results which were obtained in our institute by a group of staff workers of the Laboratory of Geochemistry of the Planets, under the supervision of Yu. A. Surkov.

The landers made the landings in an area of Venus not previously studied. Both landing sites were on the Rusalka Plain, which were adjacent on the north of this planet's vast mountain country--the Land of Aphrodite. The gamma-spectrometry method was used to determine the concentrations of potassium, uranium and thorium (table 1). These concentrations are close to those for the same elements at the landing sites of Venera-9 and Venera-10. They were characteristic for magmatic Earth rocks of basic composition and normal alkalinity—gabbro and basalts, confirming once again the basically basaltic nature of Venus's plains.

A determination of the chemical composition of the surface rocks by the X-ray-fluorescence method was also conducted at the landing site of the Vega-2 lander. A small sample was taken from the surface by drilling and was brought into the spacecraft through a system of locks, where an analysis was made, the results of which are presented in table 2. It should be noted that, while the content of the elements at the site under the lander was

Table 1.

Potassium, Uranium and Thorium Content in the Rocks of Venus's Surface, g/t

Chemical element	Venera-8	Venera-9	Venera-10	Vega-1	Vega-2
Potassium	40000±12000	5000±1000	3000±2000	4500±2200	4000±2000
Uranium	2,2±0,7	0,6±0,2	0,5±0,3	0,64±0,47	0,68±0,38
Thorium	6,5±0,2	3,7±0,4	0,7±0,3	1,5±1,2	2,0±1,0

Table 2

Content of the Main Rock-Forming Elements in Rocks of Venus's Surface, percent

Chemical compounds	Venera-13	Venera-14	Vega-2
SiO_2	45,1±3,0	48,7±3,6	45,6±3,2
TiO_2	1,59±0,45	1,25±0,41	0,2±0,1
Al_2O_3	15,8±3,0	17,9±2,6	16,0±1,8
Fe_2O_3	10,3±2,6	9,8±2,0	7,74±1,1
MnO	0,2±0,1	0,16±0,08	0,14±0,12
MgO	11,4±6,2	8,1±3,3	11,5±3,7
CaO	7,1±0,96	10,3±1,2	7,5±0,7
K_2O	4,0±0,63	0,2±0,07	0,1±0,08
SO_3	1,62±1,0	0,88±0,77	4,7±1,5
Cl	0,3	0,4	0,3

determined by the gamma-spectrometry method in a layer about 0.5 meter thick, a sample weighing several grams was subjected to X-ray fluorescence analysis. There some deviations in the results as they relate potassium.

The results of the X-ray fluorescence analysis indicated that the drill had entered rock of basic composition and normal alkalinity. As to the ratios of the main rock-forming elements, they were similar to the Earth's rocks that are formed from magma and which contain about 1 percent H_2O. This direct testimony to the existence of water below Venus's surface deserves special attention, since water exerts a strong influence on the course of magmatic processes and changes the properties of silicate melts. Also, the high content of sulfur in the rocks of the Vega-2 landing site attracts attention. It is obvious that it was concentrated here during mutual action of the rocks with sulfurous gases that are included in the atmosphere's composition.

Analysis of the data obtained by the Vega-1 and Vega-2 landers and by the Venera-15 and Venera-16 radars continues. In the future are new flights and new data, which will permit us to understand the geology of the planets better and, along with that, the geology of the Earth.

11409
CSO: 1866/128

ATMOSPHERE OF VENUS: NEW FINDINGS

Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 86 pp 19-30

[Article by Doctor of Physical-Mathematical Sciences Vasiliy Ivanovich Moroz; first two paragraphs are ZEMLYA I VSELENNAYA introduction]

[Text] The team of scientists of the Institute of Radio Electronics, USSR Academy of Sciences, and the Institute of Space Research, USSR Academy of Sciences, was awarded the USSR State Prize in 1985 for a cycle of studies, performed in 1972-1983, relating to research on the ionosphere and atmosphere of Venus.

The journal's editorial staff asked one of the winners, the head of the department of planetary physics of the Institute of Space Research, MGU [Moscow State University] Professor Vasiliy Ivanovich Moroz, to tell about recent achievements in the area of studies of the atmosphere of Venus.

Some History

The first information on the physical characteristics of the atmosphere of Venus was obtained in the 20's by means of telescopes having infrared radiometers. In spite of the rather primitive level of the infrared equipment at that time, it was possible to estimate correctly the temperature of the upper cloud boundary (approximately 230 °K) and to draw the correct conclusion that it is approximately the same on the night side of the planet as on the day. We now know that the reason for this is the enormous mass and, consequently, thermal inertia of Venus's atmosphere.

The next important step was the discovery of carbon dioxide (CO_2) absorption bands in the spectrum of Venus ((U.) Adams and (T. Danem), USA, 1932). At the same time it was as yet impossible to determine whether CO_2 is a principal component of the atmosphere. The author of this article was much occupied at the beginning of the 60's with measurements of CO_2 bands in the spectrum of Venus and was inclined to the opinion that carbon dioxide constitutes only a small part of the atmosphere.

The third step was the discovery of the planet's thermal radio-frequency emission, which indicated that its surface and lower atmosphere are very hot (ZEMLYA I VSELENNAYA, No 4, 1980, p 13 (ed.)). First there were doubts

regarding the correctness of the interpretation of the measurements; they were finally dispelled after the remarkable flight of Venus-4 (1967), when the Soviet unmanned interplanetary station for the first time sent to the earth signals from another planet. A new stage in research on Venus--studying it by means of spacecraft--began as of this time. The forerunner of the Venus-4 was the American Mariner-2, which flew past the planet at a distance of 35,000 km from it in 1962; however, it told hardly anything new about its atmosphere; then the dawn of the space age was just breaking and unmanned interplanetary stations were still "learning to fly."

Venus-4 was followed by Venus-5 and Venus-6 (1969), Venus-7 (1970) and Venus-8 (1972). Research performed with these spacecraft made it possible to firmly establish the following principal characteristics of the atmosphere of Venus:

1) The principal components of the atmosphere are carbon dioxide and nitrogen.

2) The pressure at the surface is about 90 atm.

3) The temperature of the atmosphere near the surface is about 735 °K and is reduced almost linearly with an increase in altitude to a level of $H = 55$ km .

Thus it became clear that in spite of the fact that the earth and Venus are very close in terms of principal planetary characteristics the atmosphere of Venus is not at all like that of the earth.

How did it happen that two almost identical planets possess such different atmospheres? Why does the earth have a hydrosphere and Venus is almost waterless? These questions are not only of theoretical, but also of practical importance. The atmosphere of a planet reacts subtly to external influences and it is necessary to study well the mechanisms of these changes in order not only to learn the planet's past, but also to be able to predict its future.

By understanding the evolution of the atmosphere of Venus we will better grasp the destiny of our terrestrial atmosphere and, possibly, we will find practical recommendations on protecting it from undesirable changes, including the harmful consequences of industrial activity.

The capabilities of the first Venus unmanned space station soon ceased to satisfy the requirements of scientists: There was not enough space to accomodate complex instruments, and information was transferred too slowly. Stations of the second generation--beginning with Venus-9 and ending with Vega-2--went into operation as of 1975. The program was of a combined nature: Not only was the planet's atmosphere studied, but also its surface, as well as the region of interaction between Venus and the solar wind. Let us dwell on the results of studies of the planet's atmosphere conducted recently by the Venus-15 and -16 and Vega-1 and -2.

Basic Directions of Research

Everything is interrelated in an atmosphere. For example, the chemical composition of the lower atmosphere depends on what kind of gases can "escape" the upper atmosphere as the result of thermal dissipation. The density and chemical composition of particles in clouds depend on the presence in the atmosphere of gas components capable of condensing. There can be very little of these components--hundredths and thousandths of a percentage point--but this is sufficient for the formation of particles. Minor components are able to raise the temperature of the atmosphere by hundreds of degrees if they heavily absorb radiation in the infrared region of the spectrum. The velocity and direction of the wind depend on the difference of temperatures in various regions of the planet; however, these differences are in turn smoothed out by atmospheric motion. It is possible to understand how a specific atmospheric "machine" is constructed and "operates" only on the basis of integrated research, which includes the following:

Determination of the chemical composition of atmospheric gases (whereby information on minor components, too, is required).

Studies of the thermal structure of the atmosphere (i.e., the temperature at various altitudes).

Studies of atmospheric dynamics (wind velocity and characteristics of turbulent motion).

Studies of the thermal balance of the atmosphere (quantitative characteristics of the absorption of solar radiation and the planet's thermal radiation into which the energy of the absorbed solar radiation is converted).

Studies of the chemical composition and properties of the aerosol component of clouds (the distribution of particles by size, their concentrations, etc.).

Taking into account the fact that all these characteristics generally speaking are functions of three space coordinates and of time, it can be understood that a detailed study of them is impossible in individual one-time experiments and requires longterm research cycles with the employment of complicated equipment.

Landing Vehicle, Satellite, Aerostat

Modern methods of studying Venus's atmosphere are "held up" by these three "whales." Actually, the third is not yet a "whale" but a "whalette": An aerostat in the atmosphere of Venus is a novelty which came only with Vega-1 and Vega-2.

The landing vehicle makes it possible to perform direct measurements along the path of descent when direct contact with the atmosphere's matter is employed. The technical characteristics of actual landing vehicles have afforded this possibility beginning with an altitude of approximately 63 to 64 km and down to the surface. Atmospheric sounding by means of a landing vehicle, of course, gives very detailed information, but only at one point of the planet. With the landing vehicles of the Vega-1 and Vega-2 experiments

were conducted for determining the gas composition of the atmosphere, the chemical composition of aerosol particles and their concentration, and the vertical distribution of temperature in the atmosphere.

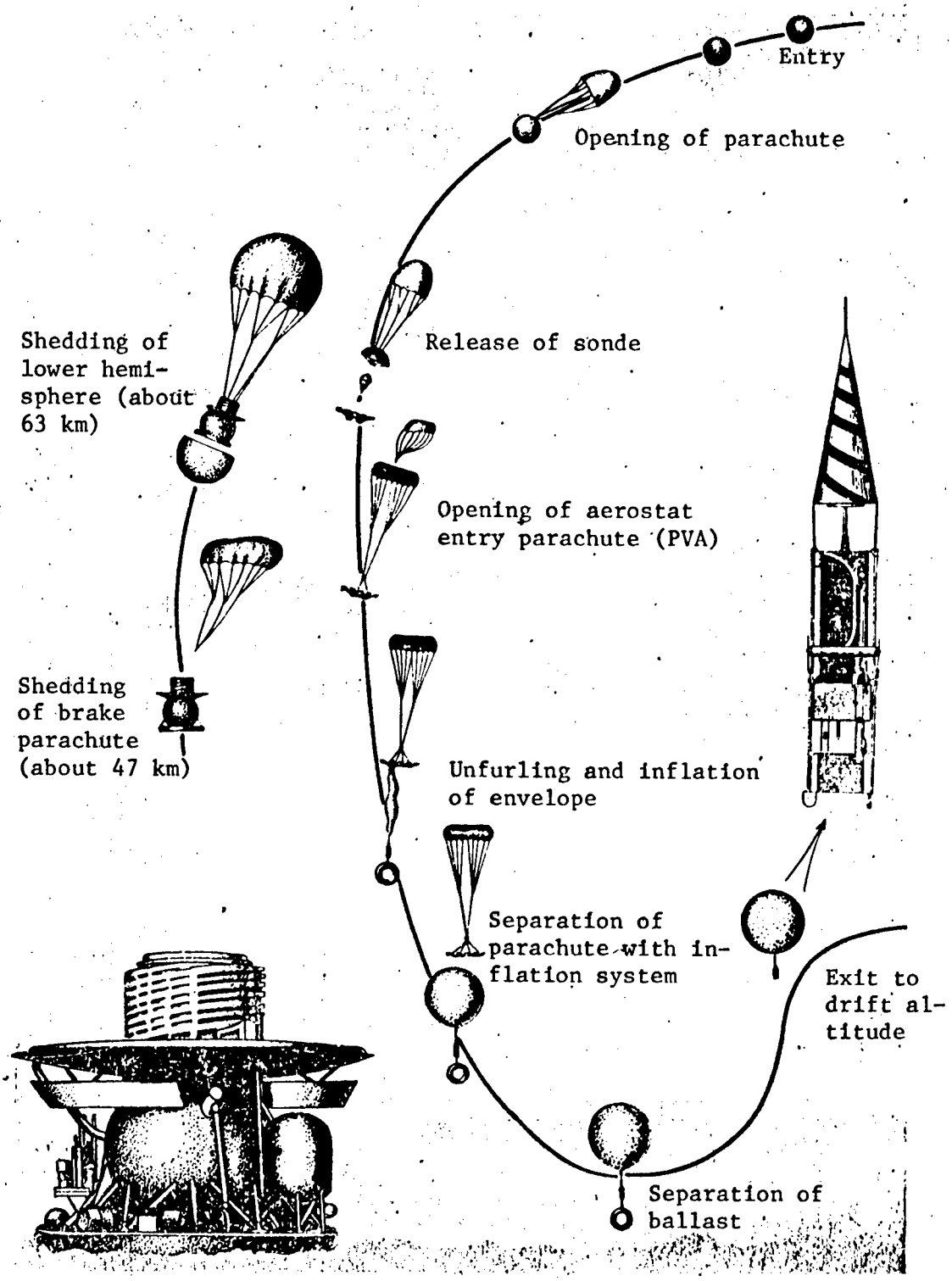
Instruments for remote atmospheric sounding are installed on an artificial planetary satellite. There are two methods of performing this sounding: passive, based on an analysis of the planet's radiation, and active--utilizing transmitted radiation. The principal objective of the Venus-15 and Venus-16 artificial satellites launched into orbit around the planet in October 1983 was radiolocation mapping of its surface (ZEMLYA I VSELENNAYA, No 1, 1986, p 13 (ed.)). A highly perfected instrument for remote sounding--an infrared spectrometer--by means of which about 1500 emission spectra of the planet were obtained in the 6- to 40-μm band and spectra relating to various latitudes and longitudes, also operated on these satellites. The vertical distribution of temperature in the atmosphere (at altitudes of 60 to 100 km), the profile of the content of particles in the upper cloud layer, and the percentage of water vapor in the atmosphere (at an altitude of about 60 km) can be "read" from each such spectrum as from a book. However, the infrared "eye" cannot peep deeper into the atmosphere than 60 km, because of its opacity. The infrared spectrometry experiment was performed on Venus-15 and -16 under the direction of the author of this article and D. (Ertel) (GDR).

With transmitted radiation it is possible to penetrate deeper into the atmosphere--to 35 to 50 km. The method consists in recording on the earth the phase and power of the spacecraft's radio signal when the edge of the planet is near the "spacecraft-earth" line (entering the "radio eclipse" zone or leaving it). Refraction in the atmosphere shifts the phase and reduces the power of the radio signal. It is interesting that a refraction phase shift (but in the other direction) also occurs when passing through the ionosphere. By employing this technique, two groups of specialists from the Institute of Radio Electronics, USSR Academy of Sciences, obtained a great number of profiles of the temperature and pressure of the lower atmosphere (O.I. Yakovlev's group) and of electronic concentration in the ionosphere (N.A. Savich et al.).

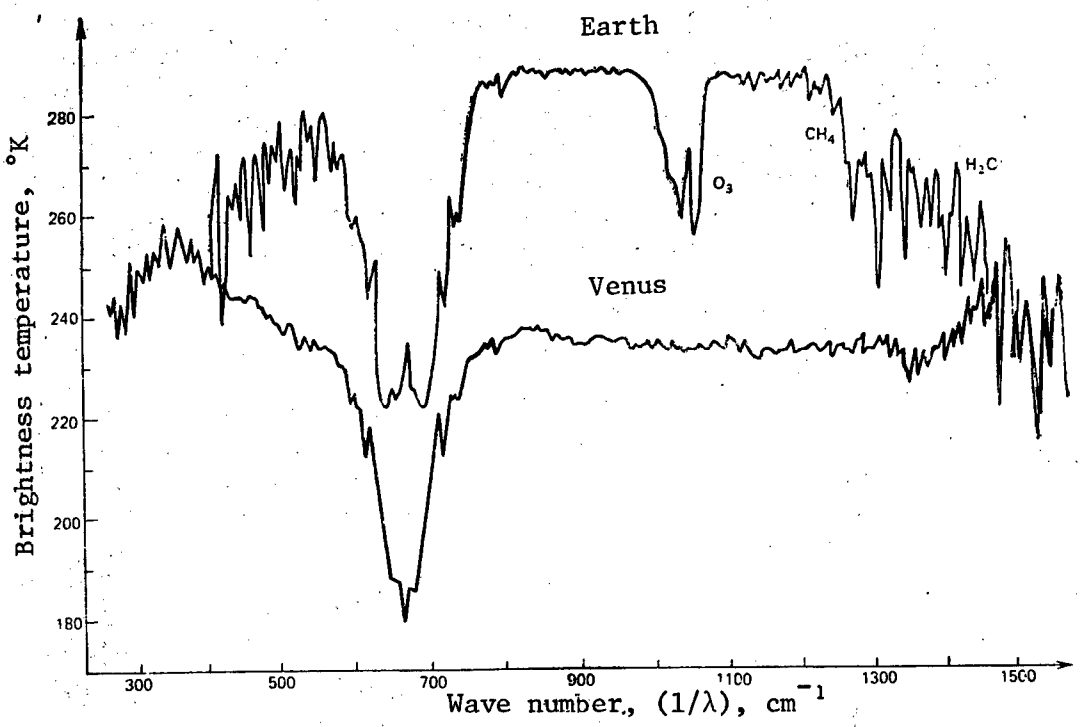
The most complicated mission fell to the lot of the Vega-1 and Vega-2 spacecraft. The scientific research director was Academician R.Z. Sagdeyev, and USSR Academy of Sciences Corresponding Member V.L. Barsukov headed the scientific research program conducted by Venus landing vehicles.

The Vega-1 and Vega-2 took off from the Baykonur space-launch complex on 15 and 21 December 1984 and took a course toward Venus. Two 24-hour periods prior to the flight up to the planet, the landing modules were separated from the space stations and then entered its atmosphere (on 11 and 15 June 1985, respectively), and the unmanned interplanetary stations themselves, after a path correction, headed into the region of the ascending node of the orbit of Halley's comet.

The landing modules consisted of two parts: a "classical" landing vehicle, and an aerostat sonde--a completely new means of studying the atmosphere of Venus.



Principal Stages in Descent of Landing Vehicle of Vega Station and Entry of Aerostat Sonde



Spectra of Infrared Emission of Venus and Earth Obtained from Space by Means of Infrared Fourier Spectrometers. The emission spectrum of Venus was registered on 17 October 1983 by the Venus-15 station, when it was over the planet's temperate latitudes. The emission spectrum of the earth was obtained on 5 July 1977 by the Meteor-28 satellite at night above southern France. The group of strong CO_2 bands forms a broad and deep absorption component with a center at about 15 μm (667 cm^{-1}). Water vapor absorption bands are also present in the spectra of both planets, but they are much weaker on Venus. Clearly, there is no ozone, O_3, on Venus, and at the same time there are no sulfur dioxide, SO_2, bands in the spectrum of the earth, whereas these bands are present in the spectrum of Venus.

An aerostat sonde floating at a specific altitude moves at the speed of the wind and makes it possible to obtain a horizontal profile (cross section) of the meteorological characteristics of the atmosphere--unlike a landing vehicle, which gives a vertical profile. The aerostat sondes of the Vega-1 and Vega-2 spacecraft were separated from the landing vehicles at an altitude of about 65 km. After braking by means of a parachute system, the envelope was unfurled and inflated with helium. Then the parachute and the inflation system were separated, the ballast was discarded and the aerostat went to the

predetermined drift altitude. The diameter of the aerostat's envelope was 3.4 m, and the total weight of the sonde was 21.2 kg (of this 12.5 kg is for the envelope with all connections, 2 kg for the helium, and 6.7 kg for the instrument car). The car has a cylindrical shape (about 1.2 m long) and is suspended on a 13-m line.

The landing of the landing modules and the entry of the aerostat sondes were performed near the equator--a landing site latitude of -8 degrees North in the case of Vega-1, and 8 degrees South in the case of Vega-2. The local time on Venus near the landing sites was about midnight. Let us note that detailed studies of the nighttime atmosphere of Venus were made for the first time.

The aerostat sonde's meteorological system contains measuring devices for pressure, temperature, vertical wind velocity, the optical density of clouds (a nephelometer) and illuminance.

The output power of the transmitter was a total of 4.5 W, and radio signals were transmitted at a wavelength of about 18 cm. The fact is that it is precisely at this wavelength that many large radio telescopes operate, united into a superlong-base-line intercontinental interferometer system (ZEMLYA I VSELENNAYA, No 1, 1983, p 4 (ed.)). This is the wavelength of the maser emission of interstellar hydroxyl (OH) molecules which form compact radio emission sources associated with regions of active star formation. Intercontinental interferometers measure the position of and distribution of luminance in these sources with angular resolution of to 0.001" (thousands of times more precisely than optical telescopes on the ground). At a distance of 1 AU this corresponds to a linear resolution of about 1 km. It is intercontinental interferometer systems of this kind which were also used for receiving signals from aerostat sondes. Such systems make it possible to determine with high accuracy the path of aerostats in the atmosphere of Venus. Measurements were performed successfully, but their processing has still not been completed. However, preliminary data are available, obtained from signal Doppler shifts, which give the speed at which the aerostats move. According to these, the aerostat of the Vega-1 traveled a path 11,500 km long, and of Vega-2 of about 11,000 km. They both worked through 46 hours each and this time was limited by the capacity of the electrical batteries.

Two interferometer networks--a Soviet and international (6 and 12 radio telescopes, respectively)--were set up for the purpose of receiving signals from the aerostats. The scientific director of the entire aerostat system was Academician R.Z. Sagdeyev, and individual aerostat experiments were headed by V.M. Linkin, V.V. Kerzhanovich and (J. Blamont) (France). The French Space Agency coordinated the work of the international interferometer network. In spite of the fact that the American government is officially not cooperating with the USSR in space research, American scientists expressed great interest in the Vega project and especially in the aerostat experiments. They took part in the reception of signals (within the framework of the international network) and in the staff of the French scientific group ("under French cover," so to speak) in development of the meteorological system in the car. Now the

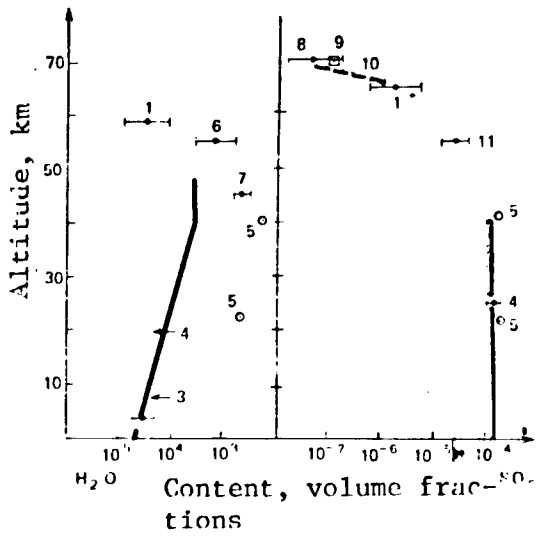
specialists of three countries are jointly studying and interpreting the measurement results.

Chemical Composition of Atmosphere

The principal components of the atmosphere of Venus are CO_2 (approximately 96.5 percent) and N_2 (approximately 3.5 percent). The list of minor components which were detected with certainly earlier in the atmosphere of Venus includes both inert gases (He, Ne, Ar and Kr) and chemically active ones (H_2O, CO, SO_2, HCl and HF). There are data on the presence of H_2, O_2, H_2S, COS and Xe, but these data are less reliable. The arsenal of experimental equipment used for studying the chemical composition of the atmosphere of Venus is quite impressive--optical spectrometry (from the earth, from a satellite and from a landing vehicle), mass spectrometers, gas chromatographs, and sensors utilizing specific gas reactions.

Water vapor and sulfur dioxide (SO_2) are of particularly great interest from the viewpoint of the chemistry of the cloud layer. Their content is a function of altitude. For example, the water vapor content is minimal at altitudes of 45 to 50 km (from 0.02 to 0.2 percent according to different measurements). Measurements performed by means of the optical spectrophotometer on Venus-11 and Venus-12 (V.I. Moroz, B.Ye. Moshkin, A.P. Ekonomov et al.) demonstrated that the water vapor content near the surface is on average approximately 0.002 percent, and at an altitude of 58 km (according to the spectra obtained with the Fourier spectrometer on Venus-15)--about 0.003 percent. New measurements of the H_2O content made under the direction of Yu.A. Surkov with the Vega-1 and Vega-2 landing vehicles qualitatively confirmed the existence of a maximum at an altitude of 45 to 50 km, but considerable quantitative discrepancies were detected with the results of earlier spectrophotometer experiments. But, on Venus, as occurs on the earth too, there can be considerable local-time variations in the content of H_2O.

Optical spectroscopy was used also on the Vega landing vehicles, but this time in a new way. Previously (on Venus-11, -12, -13 and -14) the spectrum of the solar emission "penetrating" deep layers of the atmosphere was registered. This time landing was performed at night; therefore, an artificial source--an ultraviolet xenon lamp--was used. Its rays, passing through a quartz window in the vehicle's wall, outwards, surmounted a path of about 0.8 m in the open atmosphere and were returned by means of a spherical mirror through the same window into the vehicle, where they were focused on the slit of the spectrometer. The lamp's emission was attenuated ever more greatly as the vehicle descended. Thus, studies were made for the first time of the absorption properties of the atmosphere of Venus below 60 km in the range of 2200 to 4000 A. It was possible to detect a broad absorption band whose nature has still not been finally established. It is most probable that the absorbing substance is gaseous sulfur, S_8. If this is so, then its content is about 0.001 percent at an altitude of approximately 40 km. (The scientific directors of the experiment were the author of this article and (Zh.-L. Berto), France).



Vertical Profiles of Content of H_2O and SO_2 in Atmosphere of Venus from Data of Various Experiments: 1--infrared Fourier spectrometer (Venus-15); 2--ground spectroscopy observations, 0.082 μm band; 3--spectrophotometry on Venus-11, -12, -13 and -14 landing vehicles (0.82 and 0.95 μm bands; 4, 5 and 6--gas chromatography on Venus-12, Pioneer sonde and Venus-13, respectively; 7--electrolytic measuring devices on Venus-13 and -14 and Vega-1 and -2; 8--ground observations of SO_2 bands in 0.3 μm region (E. Barker); 9--measurements of SO_2 bands in 0.2 to 0.3 μm region from Pioner sonde; 10--ground observations of SO_2 bands in 0.3 μm region (interpretation of E. Barker's data in study by L.V. Zasovaya et al.); 11--photometry in 0.36 μm region on Venus-14

Thermometer and Barometer--What Can Be Simpler?

The question is totally valid, but for some reason there have been difficulties with the answer for a long time. The temperature and pressure measuring devices on Venus-13 and -14 (1982) actually differed little from the measuring devices on Venus-8 (1972). The temperature and pressure on the planet's surface, as well as the approximate variation in these parameters with altitude, were already known for a long time. But the accuracy of the measurements had to be increased.

Precision measurements of temperature and pressure were made on board the Vega spacecraft. Resistance thermometers and Aparoid pressure transducers were used for these measurements. The experiment was performed under the direction of V.M. Linkin (IKI AN SSSR [Institute of Space Research, USSR Academy of Sciences]) in cooperation with French scientists (J. Blamont et al.).

The results of direct measurements link directly to determinations of temperature profiles of the mesosphere conducted by means of the infrared spectrometer on Venus-15. By analyzing the set of data, it is possible to form general conclusions:

At altitudes of from 0 to 90 km systematic 24-hour variations in temperature are very slight--they do not exceed a few degrees.

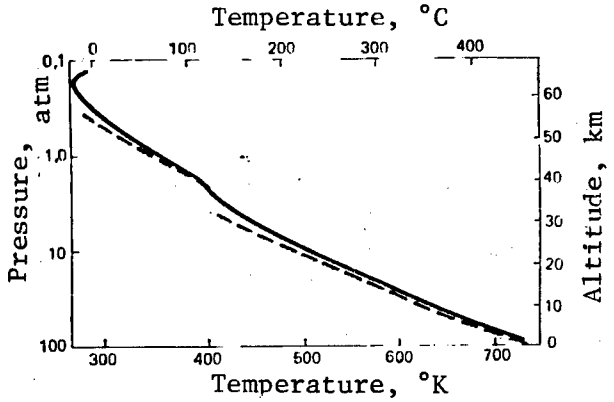
In the troposphere--below 55 km--the variation in temperature is close to linear; however, it is not adiabatic everywhere.

Below 40 to 45 km the temperature of the atmosphere does not depend on the latitude.

At altitudes greater than 40 to 45 km a dependence of the temperature on the latitude of the site is observed, and at altitudes of 60 to 100 km the qualitative character of the profiles varies with latitude: In the latitude region of $\phi \leq 60$ degrees it is monotonic, and at high latitudes there is usually inversion (minimum temperature at an altitude of approximately 75 km) or isothermy.

Local-time variations of a random nature with a range of 10 to 15 degrees are encountered at altitudes greater than 55 km.

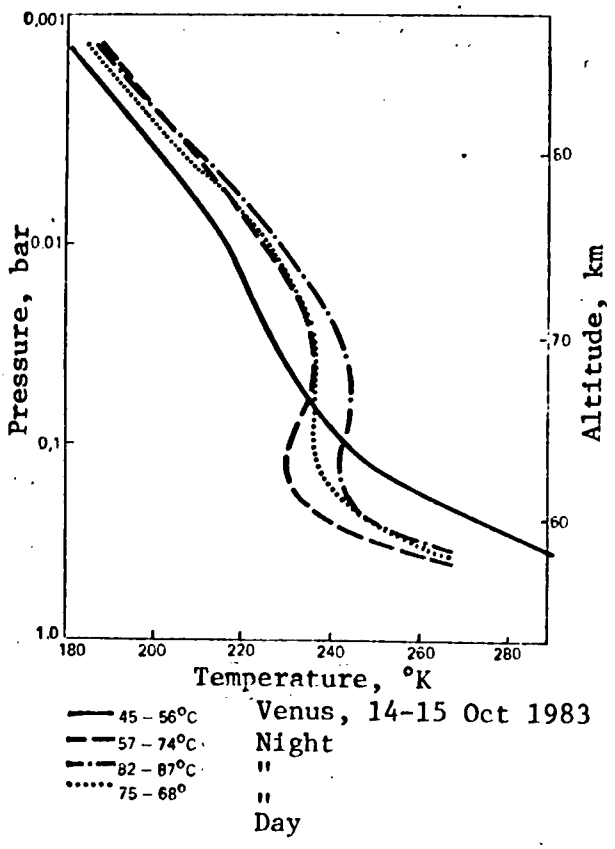
The absence of systematic 24-hour variations is explained by the enormous thermal inertia of the lower atmosphere. The stability of rarefied mesospheric layers is associated with the fact that the energy which they obtain from the lower atmosphere, on account of its thermal emission, is substantially greater than direct solar heating. And since these lower layers do not experience 24-hour temperature variations, the temperature of the mesospheric layers is also stable.



Dependence of Temperature, T , on Pressure, p , and Altitude, H , Above Surface of Planet, Obtained by Means of Vega-2 Landing Vehicle. The slope of the actual curve is either less than the adiabatic or the same. In the first case the atmosphere is stable, i.e., convective

[Continued on following page]

motion is absent; in the second, convection takes place. It is clear from comparing these curves that there must be two convection zones in the atmosphere of Venus: One of them adjoins the surface (altitudes of 0 to 35 km) and the second coincides in altitude with the lower and middle sections of the cloud layer.



Examples of Altitude Profiles of Temperature Determined from Infrared Spectra (Venus-15 Fourier Spectrometer)

Aerosol, or Simply, Turbid Medium

A long time ago astronomers had already arrived at the certainty that they cannot see the surface of Venus in a telescope because of the fact that the planet is enveloped by a cloud canopy. Strictly speaking, we would not see anything even without the clouds: The gas layer of the atmosphere is too great and the Rayleigh molecular scattering alone is enough to make details on the planet's surface almost indistinguishable.

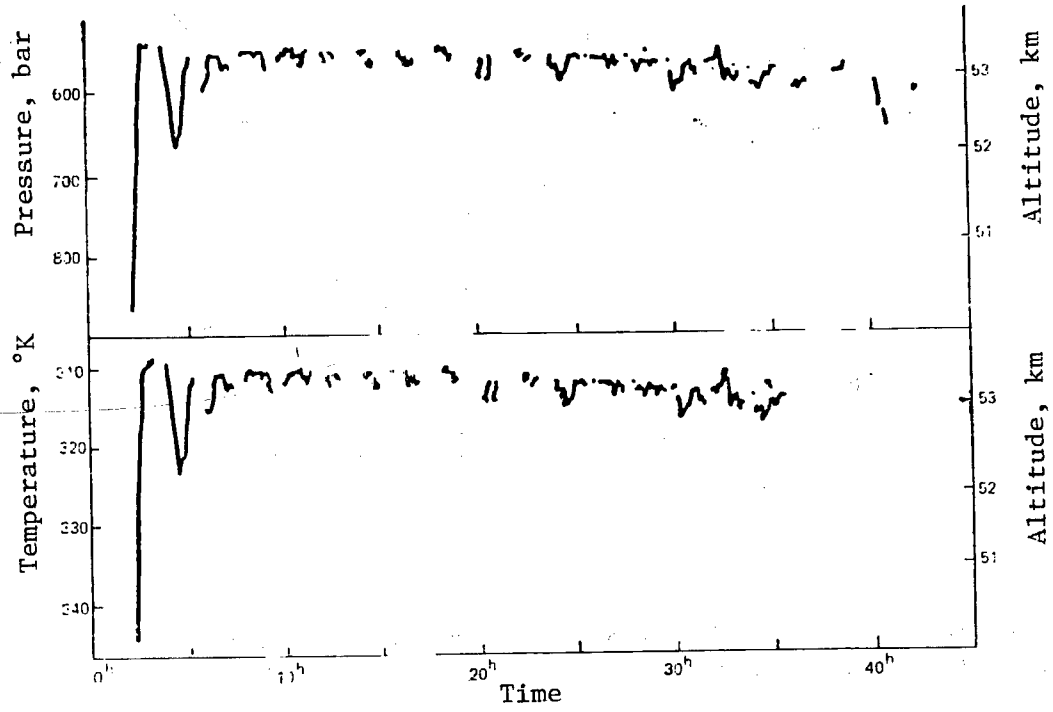
But one way or another clouds exist on Venus and they form a continuous cloud canopy without breaks. The infrared emission "tells" about this best. The typical brightness temperatures of the planet in the IR band are 220 to 240 °K (wavelength of about 10 μm) and 250 to 270 °K (at the wavelength maximum of about 28 μm). It is impossible to explain such low brightness temperatures

without a dense aerosol medium. If all the data are gathered together, then the structure of the aerosol medium in the planet's atmosphere seems to be as follows:

The principal cloud layer has a thickness of about 20 km (with boundaries at altitudes of 65 to 70 and 45 to 50 km), and about 100 particles with a diameter on the order of 1 μm are contained in one cubic centimeter of it.

Above the principal layer, right up to an altitude of approximately 90 km, there is very rarefied (1 to 10 particles per 1 cm^3) supernebular haze.

Subnebular haze, also rarefied (approximately 1 cm^{-3}) is located below the principal layer--right down to an altitude of approximately 30 km.

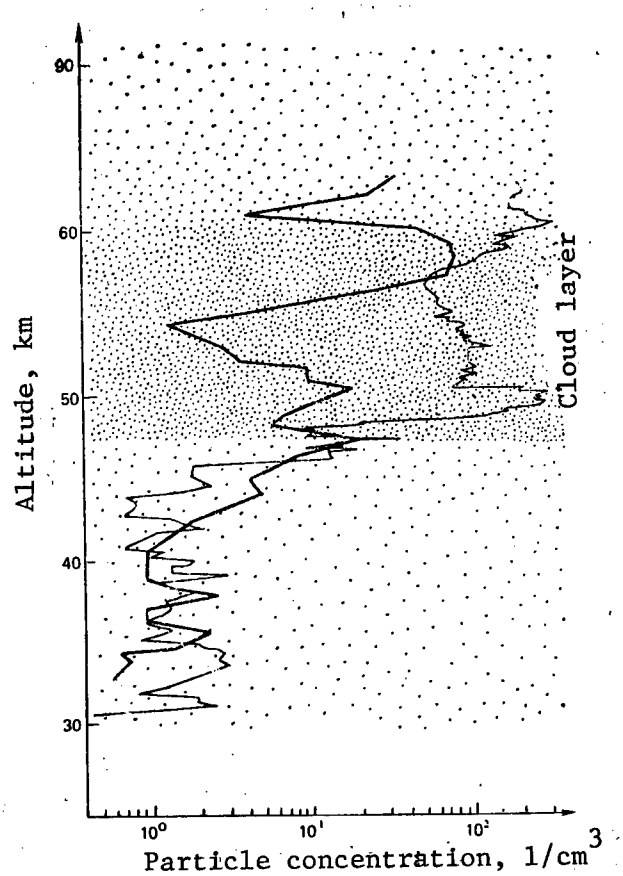


Variation in Temperature and Pressure on Flight Path of Aerostat Sonde of Vega-1 Station on 11 June 1985. With the appropriate choice of scales both curves almost agree. This means that the temperature variations observed are explained by variations in the "floating" altitude of the aerostat. It is obvious that these variations are of the nature of "spurts," pointing primarily downward. The "spurts" are caused by the motion of the aerostat in the convection zone, and their predominant direction is probably associated with the fact that the flight path passed through the upper sections of convection cells.

Even in the principal cloud layer, optical visibility is great--a few kilometers (in terms of terrestrial concepts this is rather fog, but, as they say, everything is relative). The position of the lower boundary of the cloud layer and an estimate of the scattering coefficient deep within it were found for the first time in the nephelometric experiment in the Venus-9 and -10 landing vehicles in 1975 (ZEMLYA I VSELENNAYA, No 3, 1976, p 3 (ed.)) by M.Ya. Marov and his coworkers. Detailed information on the distribution of particles by size can be obtained only by using aerosol spectrometers--optical instruments which register the passing of individual particles through a small field of view. Such an experiment was performed prior to the Vega a total of once--with the American Pioneer sonde (1978). Two different aerosol spectrometers each operated on the Vega-1 and Vega-2 landing vehicles. The results demonstrated that the subnebular haze is considerably denser at the landing sites of our latest vehicles, and the relative number of large particles in the principal layer is much smaller than where the Pioneer spacecraft descended.

What can be said about the chemical composition of the particles? Bands for sulfuric acid in the liquid phase are quite visible in the infrared spectra. This testifies to the fact that the upper portion of the clouds (to an altitude at least on the order of 60 km) contains many particles consisting of sulfuric acid, or, perhaps, only such particles. There are almost no data on greater depths. In 1978 Yu.A. Surkov and his coworkers for the first time made on Venus-12, using the landing vehicle, an experiment on gathering particles and analyzing them, by employing an x-ray fluorescent emission spectrometer. The essence of the method is as follows: The material being studied is exposed to hard radiation, which excites deep-lying electron shells and forces them to emit x-ray quanta. This is the so-called characteristic emission and from its spectrum it is possible to identify the elemental composition of the "target." As a result of the experiment it became clear that the particles of the clouds of Venus contain sulfur and chlorine. With the sulfur everything is completely explainable (since there is sulfuric acid), but to this time it is not clear to which compound the chlorine is to be attributed.

An entire series of experiments on determining the chemical composition of the particles was performed with the landing vehicles of the Vega-1 and -2. B.M. Andreychikov, L.M. Mukhin and their coworkers considerably modified the method employing an x-ray fluorescent emission spectrometer and were able to obtain good altitude resolution. The result turned out to be striking: There is sulfur and there is chlorine, but they, it appears, form rather narrow layers which do not coincide in altitude! Phosphorus was also found, apparently, in addition to sulfur and chlorine. Two other experiments were aimed at the direct detection of sulfuric acid in the aerosol. The particles were collected by special filters and were subjected to chemical treatment, whereby the H_2SO_4 decomposes into SO_2 and H_2O. In one experiment the decomposition products were measured by a mass spectrometer (Yu.A. Surkov and his French colleagues--(G. Izrael) and (R. Toma)), and in another by a gas chromatograph (the group under the direction of L.M. Mukhin). Both experiments demonstrated that H_2SO_4 is present in a quantity of about 1 mg/m$_3$ at altitudes of 47 to 63 km.



Concentration of Aerosol Particles in Atmosphere from Data of Direct Measurements. The concentration is given of all particles whose diameter exceeds a certain linear value (0.6 μm in the case of the Pioneer and 0.7 μm in the case of the Vega). It is obvious that the cloud layer has complicated stratification and its nature is different above the landing sites of the landing modules of the Vega-2 and Pioneer, although there are also common features: In both cases it is possible to distinguish three principal "sublayers"--an upper, middle and lower--and the concentration is minimal in the middle.

The totality of the data makes it possible to think that below 60 km there are aerosol particles consisting not only of sulfuric acid, but also of some other substance and, perhaps, they are much more predominant in terms of mass than the sulfuric-acid. The interpretation of the data obtained by the Vega-1 and Vega-2 spacecraft has still not been completed. Possibly it will make it possible to obtain an answer to this question. One candidate is elemental sulfur.

Atmospheric Hotbed

The clouds of Venus reflect solar radiation very well. The combined characteristic defining the planet's mean reflectivity is its spherical albedo, A . On Venus A = 0.76 , i.e., approximately twofold greater than on the earth. A percentage of the solar radiation, 1 - A , is absorbed by the planet and heats it. The thermal (infrared) radiation flux going off into space must be precisely balanced by the energy arriving. In the case of Venus the flux of this radiation is the same as from an absolutely black body with a temperature of 230 °K (the temperature of an equivalent absolutely black body is called the effective temperature of the planet).

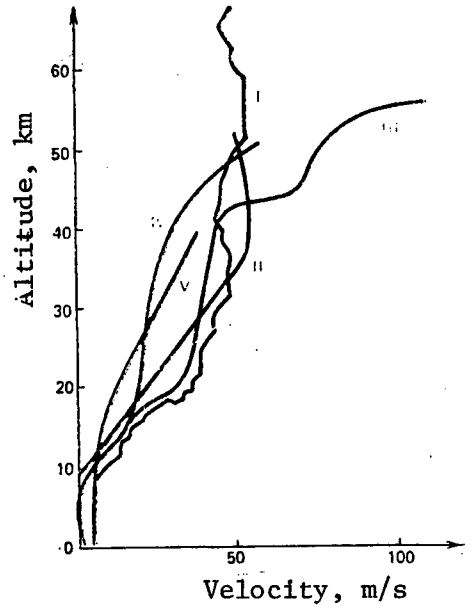
But, how does one combine the low value of the effective temperature (230 °K) with the high temperature of the surface (approximately 735 °K)? The apparent contradiction is explained by the hotbed effect. As we know, it consists in the fact that even a small quantity of solar radiation penetrating to the surface can heat it to a high temperature. The atmosphere's penetrability for solar (or shortwave) radiation is only one necessary condition. There is a second one--the atmosphere must heavily absorb its own thermal radiation (i.e., longwave). Determination of the chemical composition of atmospheric gases and the measurement of solar radiation flux and the characteristics of clouds have demonstrated that both conditions are fulfilled not only qualitatively but (at least in a first approximation) also quantitatively: The hotbed effect is precisely the physical mechanism which is responsible for the high temperatures in the lower layers of the atmosphere and on the surface of the planet.

Superrotation--Eternal Hurricane

The doctoral dissertation of USSR Academy of Sciences Corresponding Member G.S. Golitsyn--the famous specialist in atmospheric dynamics--began with the phrase: "The winds blow on the planets." What is true is true, and with respect to Venus it is true "squared." The entire planet is encompassed by powerful zonal (i.e., directed latitudinally) circulation. At altitudes of 60 to 70 km the wind velocity reaches approximately 100 m/s. The motion of the clouds near the upper boundary creates the impression that the planet is rotating rapidly, making one revolution per 4 24-hour periods, although (as radiolocation measurements have demonstrated) the solid body of the planet has a period of rotation of about 243 24-hour periods). From measurements made with landing vehicles (V.V. Kerzhanovich et al.) the wind velocity is reduced as the surface of the planet is neared, and below 10 km it becomes a total of on the order of 1 m/s. Longterm aerostat measurements of wind velocity (they were performed at an altitude on the order of 54 km at equatorial latitudes) demonstrated that on average the wind velocity equals about 70 m/s.

Such powerful zonal circulation on a slowly rotating planet is a phenomenon which is difficult to explain. Several possible hypotheses have been suggested. One of them is that the energy of convective motion in the cloud layer is converted into the energy of ordered motion. A cardinal verification of this hypothesis could be performed if it were possible to eliminate totally the cloud layer: The atmosphere would become transparent in the IR band. Then convective motion would cease and if the hypothesis is true superrotation

should disappear. But, unfortunately, only a mental experiment of this kind is possible. But the only real way to find an answer is to accumulate information on the features of atmospheric motion on Venus. And the principal role here can be played by aerostats; but two aerostats are too little to directly trace "lines of flow" in the circulating motion of the planet's atmosphere. However, the measurements made with them have already given important scientific results. They have demonstrated that there is considerably more intense convection at altitudes of 53 to 54 km than had been assumed earlier. Most probably, the energy necessary for superrotation is actually "pumped over" from the energy of convective motion.



Vertical Profile of Zonal Wind in Atmosphere of Venus from Data of Measurements with Landing Vehicles: I--Venus-12; II--Venus-9 and -10; III--Venus-8; IV--Pioneer-Venus day sonde; V--Pioneer-Venus north sonde

Is It Dark on Venus at Midnight?

As recently as a year ago the author of this article gave a rather smart answer to this: It does not get darker. The answer is true also now, if the visible waveband is meant. However, it is necessary to make a refinement. You see, the surface of the planet is heated to a high temperature, and beginning with wavelengths of about 1 μm the intensity of this radiation becomes rather pronounced. It is precisely at such a wavelength that the transmission spectrum of atmospheric gases has a spectral window, and the rather considerable radiant flux leaving from the surface seeps upward--right up to altitudes of 40 to 60 km. It was measured for the first time at these

altitudes with the landing vehicles and aerostat sondes of Vega-1 and -2, although its thermal radiation was registered earlier near the surface by the Pioneer sondes. Prospects have been opened up for future expeditions to obtain panoramic images of the surface by utilizing its thermal self-radiation.

And so, why are they so different, Venus and the Earth?

It looks like we are already close to an answer. The most important difference, evidently, is the completely different amounts of water on the surface, although no less important is the enormous difference in the amounts of atmospheric carbon dioxide. Both features are closely related, since liquid H_2O dissolves CO_2 marvelously and converts it into the bound state: Carbon dioxide dissolved in water reacts with silicates and they are converted into carbonates. The amount of carbon dioxide bound by this process on the earth is approximately the same as in the atmosphere of Venus. And so, it is probable that the deficiency of water on Venus is a fact of primary importance and one which has determined the particular fate of the planet--to be very hot. Four hypotheses for explaining the deficiency of water have been advanced at various times:

1) Venus was formed with a small quantity of H_2O because of the fact that in the protoplanetary nebula there were no ice particles at the appropriate distance from the sun (approximately 0.7 AU).

2) The water on Venus is bound in rocks.

3) The "escape" of hydrogen from the upper atmosphere of Venus (thermal dissipation) resulted in the exhaustion of the originally large supplies of water.

4) At its initial stage of formation Venus had the same atmosphere as the earth, but lost it as the result of a space catastrophe--a collision with a large body the size of the moon or even of Mars.

The first hypothesis is improbable, since the water in particles from which planets accumulated was contained more likely not in the form of ice but in the form of crystallized water (bound in minerals). The second hypothesis does not "pass" quantitatively, although rocks do exist which retain H_2O at high temperatures. The third seems more plausible, since the measured (though not quite verified) ratio of hydrogen isotopes, D/H , on Venus is approximately 100 times greater than the earth's. This testifies to the fact that Venus actually lost a considerable amount of hydrogen (and this means also of H_2O). However, quantitative calculations based on this hypothesis show that the original mass of Venus's hydrosphere all the same had to be much less than that of the earth (V.A. Krasnopolskiy). The fourth hypothesis--the "catastrophe"--originated quite recently as the result of one study on the mathematical modeling of collisions in a protoplanetary nebula. This study ((Dzh. Vezerill), USA, 1985) demonstrated that the probability of collisions of large protoplanetary bodies--already close to the "completion of

construction"--is rather high and cannot be ruled out. Possibly, here is the answer; but we will be cautious. Venus has been studied very intensely in recent years, but there are still a lot of "blank spaces" and it is too early to say that we completely understand the atmosphere of this planet.

8831
CSO: 1866/143

UDC: 523.031:523.44

GAMMA SPECTROMETRY OF MINOR BODIES IN SOLAR SYSTEM

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 17 May 85) pp 631-638

[Article by Yu.A. Surkov, L.P. Moskaleva and O.S. Manvelyan]

[Abstract] The possibility of determining the elemental composition of the surfaces of minor bodies in the solar system, such as asteroids and the Martian satellites Phobos and Deimos, using a γ-spectrometer carried aboard a spacecraft, is examined on the basis of published computations and the results of earlier experiments for studying the γ-radiation of the Moon and Mars. Now computations have been made to determine the dependence of the flux of γ-quanta on altitude for spherical bodies with a radius from 13 to 500 km. The accuracies in determining the main rock-forming elements when making measurements in a geometry close to 2 and using a γ-spectrometer with an NaI (Tl) crystal measuring 100 x 100 mm were estimated. The time required for discriminating the effect caused by the characteristics of γ-radiation of surface rocks as a function of altitude was calculated. The total fluxes of γ-quanta with an energy > 0.5 MeV differ substantially for different types of rocks (for example, 0.45, 0.9 and 2.7 $\gamma/(cm^2 \cdot s)$ for chondrites, basalts and granites respectively). Measurement of the total flux of γ-quanta emanating from the surface of a celestial body therefore makes it possible to determine, with an accuracy to 30 percent, the type of rocks making up the surface. It was found that without an equalization of the velocities of the probe and celestial body measurements could be made only during a flyby at distances < 0.1 R (in the case of large asteroids); for bodies of a lesser radius of determination of the composition of surface rocks would be possible only with an equalization of velocities. Calculations were made to ascertain the time that a spacecraft would have to remain at a definite distance from the studied body for such purposes. For measurements at a distance equal to the radius of the studied body the spacecraft would have to hover above the surface for approximately 15 minutes for a reading with a 30 percent error.

Figures 4, references 16: 10 Russian, 6 Western.

5303/8309
CSO: 1866/4

UDC: 523.42

POLAR IONOSPHERE OF VENUS NEAR THE TERMINATOR BASED ON RADIO OCCULTATION DATA SUPPLIED BY VENERA-15, 16

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 21 May 85) pp 448-454

[Article by N.A. Savich, V.Ye. Andreyev, A.S. Byshlov, A.L. Gavrik, V.V. Klimov, V.P. Konofalov, N.V. Laptev, V.A. Marmulev, A.P. Mesterton, A.S. Nabatov, I.K. Osmolovskiy, L.N. Samoznayev, D.Ya. Shtern]

[Abstract] The Venera-15 and -16 planetary satellites were equipped with coherent transmitters allowing repeated dual frequency transradiation of the Venusian ionosphere. This article presents results characterizing the status of the plasma near the planet in the polar regions for solar zenith angles of 90-96°, i.e., the transition zone between the day and night sections. Eleven altitude profiles of distribution of electron concentrations were obtained. There is a lower ionization maximum on N(h) profiles between 90 and 91.2°, indicating the importance of solar ionizing radiation on the formation of the Venusian ionosphere in this interval of solar zenith angles. At 92-96°, the distribution of electron concentration may have either one or two ionization maxima. Concentration in the upper maximum decreases smoothly with increasing z_{sun}, while in the lower maximum it is practically independent of it. The height of the Venusian atmosphere near the terminator is generally a few hundreds of kilometers. A plasma layer with almost constant electron concentration of about 10^3 cm^{-3} is formed at altitudes of over 200 km.

Figures 3, references 11: 5 Russian, 6 Western.

6508/8309
CSO: 1866/141

UDC: 523.5-3

VERY LONG BASELINE INTERFEROMETRY EXPERIMENT WITH RADIO OCCULTATION OF NEAR SOLAR PLASMA USING VENERA-15 AUTOMATIC INTERPLANETARY PROBE SIGNALS

Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 12 No 6, Jun 86 (manuscript received 23 Dec 85) pp 486-492

[Article by V.A. Alekseyev, V.I. Altunin, A.V. Biryukov, E.D. Gatelyuk, A.F. Dementyev, I.A. Knorin, N.A. Knyazev, A.Ye. Kryukov, B.N. Lipatov, V.A. Radakov and A.S. Sizov, RAdiophysics Scientific Research Institute, Gorkiy and USSR Academy of Sciences Space Research Institute, Moscow]

[Abstract] Narrow band (less than 1.5 kHz) transmissions from the "Venera-15" Venus probe in the 30 cm band were received 27 June 1984 using the 1,200 km baseline of the Crimea (70m) to Podmoskovye (25m) VLBI system. The signals were observed when Venus was behind the sun about 250 million km from Earth with a visual angle between the sun and Venus of 3°10'. Two recordings, each 200 s long, were made; the received signals exhibited strong amplitude and phase fluctuations from the influence of the near-solar plasma. Data on this turbulent medium is contained in the distorted spectrum of the interference fringe. The average spectral line shape of the fringe and its width are determined and a change in the line width from 7.9 Hz to 9.5 Hz was recorded over the 20 minute period between the two recordings. The spectral response of the equipment was checked against the nonocculted emissions from quasar 3C454.3 Solar plasma inhomogeneities of less than about 500 km had the greatest influence on the VLBI system response. The authors are grateful to S.L. Azarkh, N.M. Antsibor, B.S. Bludov, V.P. Davydov, S.P. Ignatov, Yu.M. Kruglov, A.S. Kukharskiy, Ye.P. Molotov, V.V. Selivanov and I.D. Tsirenina as well as the personnel servicing the radiotelescopes for their assistance in the work.

Figures 3, references 14: 12 Russian, 2 Western.

[129-8225]

/8309

INTERPLANETARY SCIENCES

UDC: 523.72:523.42

PROPERTIES OF VENUSIAN IONOSPHERE AND ITS SOURCES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 22 May 85) pp 106-121

[Article by T.K. Breus, M.I. Verigin, and K.I. Gringauz]

[Abstract] Data from the Venera-9 and Venera-10 Venus probes in October and November of 1975 are used to plot the profiles of the electron concentration for the day and night sides of the planet. These occultation data clearly show the concentration profiles as a function of altitude from 100 to 680 km. This extensive survey paper also draws on data for the diurnal changes in the ion composition and the altitude distribution of the ion concentration derived from the Pioneer Venus probe. Nonsteady-state and small scale phenomena in the ionosphere are discussed in light of these data and followed by details of efforts to model the ionospheric processes. The experimental data in the nighttime and daytime ionosphere show significant scatter, both because of procedural and natural physical reasons. Although the qualitative behavior of the ionosphere (especially its daytime component) is quite satisfactorily described quantitative descriptions are not reliable. The question of the sources of the ionization and the mechanism for the formation of the nighttime ionosphere is unresolved. The fact of the existence of ionizing electron fluxes with energies on the order of several tens of eV in the nighttime ionosphere has been reliably established both by Soviet and American data. The level of these fluxes is sufficient to produce electron concentrations comparable to those observed, so that any model of the nighttime ionosphere must consider the effect of these fluxes.

Figures 9, references 59: 9 Russian, 50 Western.

[101-8225]

/8309

UDC: 551.510.53

ELECTRICAL AND ELECTROTHERMAL CONDUCTIVITIES OF PLANETARY IONOSPHERES. II. EARTH, MARS, VENUS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 26 Apr 84) pp 122-127

[Article by A.V. Pavlov]

[Abstract] The first part of the present paper (KOSMICHESKIYE ISSLEDOVANIYA, 1984, Vol 22 No 5, p 781) derived equations for the electrical and electrothermal electron conductivity tensors in an arbitrary, multicomponent, nonequilibrium mixture of gases; the second part applies the equations to the calculation of these conductivities in the daytime ionospheres of the Earth, Mars, and Venus using first, second and third order approximations of an expansion in terms of Sonin polynomials by means of the Chapman-Enskog method. The conductivities are computed in Cartesian coordinates and the ionosphere is considered to be a thin shell with a nonconductive bottom. The various directional components of these conductivities are found for the three planetary atmospheres as a function of the magnetic field and altitude. When the magnetic field increases, the altitude above which the coefficients of ion conductivity make a marked contribution to the overall conductivity of the ionosphere decreases. The overall conductivity parallel to the magnetic field is approximately the same as the electrical conductivity parallel to the field up to 220 km in the ionospheres of Mars and Venus (within 10 percent). The first order approximation for the electrical conductivity can be used in practical calculations above 90 km in the Earth's ionosphere (with a precision no worse than 1 percent). A first order approximation must be used for these coefficients on Mars and Venus when the magnetic field is greater than 100 gamma and a second order approximation is required when the field is less than about 10 gamma. There are practically no thermal currents in the perpendicular and transverse directions relative to the magnetic field in the Earth's ionosphere. The second order approximation of the coefficients of electrothermal conductivity can be used for estimates of the thermal currents in this case. The third order approximation must be used for the electrothermal conductivity coefficients in the ionosphere of all three planets for quantitative estimates.

Figures 4, references 16: 6 Russian, 8 Western, 2 Western in Russian translation.

[101-8225]
/8309

UDC: 621.317.523.40

LUNAR PALEOMAGNETISM AND PROBLEM OF DYNAMO-FIELDS OF PLANETS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86
(manuscript received 22 Jul 85) pp 128-137

[Article by Sh.Sh. Dolginov]

[Abstract] Despite considerable progress in the development of the dynamo theory and the magnetic mapping of the solar system, the problem of the origin and mechanism involved in the magnetic fields of the planets remains unresolved. This paper presents the relevant data on lunar paleomagnetism obtained in the near-equatorial region in order to examine the hypothesis that a dynamo field in the fluid conducting core of the moon is responsible for lunar magnetism. Using a precessional dynamo model of the moon and assuming that satellites existed 3.8 to 4 billion years ago in near-equatorial orbits, it is shown that such satellites could have resulted in the production of a dynamo field of 10^{-4} T. The case for a past dynamo field is supported by data showing the field intensity as a function of the age of lunar rock and data on the slow weakening of this field with time. The intense dynamo field decayed as the satellites fell to the lunar surface, but a more moderate dynamo field could be generated with the precession of the moon subject to the perturbing influence of the Earth's gravitational field. This precessionally produced field also decayed as the moon became more distant from the Earth and acquired its synchronous rotation. If future studies of the paleomagnetic fields of the moon from low altitude satellites in polar orbits confirm and more precisely define the topology of the paleoequators and paleopoles of the ancient dynamo field, then the origin of this field will be well established. This would be the energy stored in the rotating moon, transformed to magnetic energy through precessions related to lunar precession, since the precession-dynamo model is a good description of the magnetic states of all of the planets studied thus far as well as the moon in the present epoch.

References 53: 4 Russian, 46 Western, 3 Western in Russian translation.

/8309

UDC: 523.4

GEOMORPHOLOGICAL CHARACTERIZATION OF NORTHERN HEMISPHERE OF VENUS

Moscow GEOTEKTONIKA in Russian No 4, Jul-Aug 86 (manuscript received 10 Nov 85) pp 4-25

[Article by V.L. Barsukov, A.L. Sukhanova, A.L. Akim, Yu.N. Aleksandrov, A.T. Bazilevskiy, M.Yu. Berman, N.N. Bobina, A.F. Bogomolov, I.M. Bokshteyn, G.A. Burba, S.A. Kadnichanskiy, V.A. Kotelnikov, M.A. Kronrod, V.P. Kryuchkov, L.V. Kudrin, R.O. Kuzmin, M.S. Markov, O.V. Nikolayeva, G.M. Petrov, A.A. Pronin, O.N. Rzhiga, L.B. Ronka, Yu.I. Sidorov, G.M. Skrypnik, Yu.S. Tyuflin, I.M. Chernaya, P.A. Chochiya and V.P. Shashkina, Institute of Geochemistry and Analytical Chemistry imeni V.I. Vernadskiy, USSR Academy of Sciences; Geology Institute, USSR Academy of Sciences; Institute of Radioelectronics, USSR Academy of Sciences; Special Design Bureau of Moscow Power Engineering Institute; Central Scientific Research Institute of Geodesy, Aerial Photography and Cartography; Institute of Applied Mathematics, USSR Academy of Sciences; Institute of Problems of Information Transfer, USSR Academy of Sciences, and Wayne State University, United States]

[Abstract] In 1983-1984 the Venus-15 and -16 orbital stations made radar observations of the northern hemisphere of Venus from the pole to about 30 degrees north latitude in an area of about 115 million square meters with resolution of 1 to 2 km. Operating along with the radar was an altimeter with vertical resolution of 50 m. The image strips were assembled into a photomosaic on a scale of 1 : 4,000,000. Interpretation of the photographs is continuing. A characterization is presented of the most general features of the morphology of the surface of Venus in accordance with the present interpretation. Traces of erosion and sedimentation are not observed in the images and it is therefore assumed that the relief and roughness of the surface are a direct expression of tectonic, tectonomagmatic and volcanic processes. The authors have no single opinion regarding the genesis of structures of various types on Venus. The data reveal a complicated volcanic and tectonic relief. Most of the territory photographed is occupied by low-lying basaltic plains with numerous volcanic vents and mudflows and individual

shield volcanos. Complex systems of linear and areal dislocations caused by horizontal stresses have developed in uplands. The annular forms are represented by large volcanotectonic structures and impact craters. It is estimated from the density of the craters that the average age of the plains is 500 million to one billion years. Brief discussions are presented of the planetary orography; plains, including smooth plains, smooth rolling plains, hilly mesa plains, and banded plains; linear dislocation zones; uplands, including the Lakshmi Plateau and its setting; the "parquet" or Tessara Fortunae; and the Beta, Bell and Ulfrun uplands; circular structures, including ovoids, impact craters and circular structures of unclear origin; and relief-formation processes, including volcanism, tectonic and tectono-magmatic processes, impact processes and exogenic processes. It is concluded that the absence or extremely low degree of large-scale erosion and sdeimentation on Venus and, accordingly, preservation of a direct tectonic and volcanic relief make Venus an exceptionally useful subject of study for the purpose of comparing it with the Earth at the very early stages of Earth's development.

Figures 20, references 26: 14 Russian, 12 Western.

[20-8831]

/8309

UDC: 551.24+523.4.42

STRUCTURE OF LAKSHMI PLATEAU AS EVIDENCE OF HORIZONTAL ASTHENOSPHERIC FLOWS ON VENUS

Moscow GEOTEKTONIKA in Russian No 4, Jul-Aug 86 (manuscript received 10 Nov 85) pp 26-41

[Article by A.A. Pronin, Institute of Geochemistry and Analytical Chemistry imeni V.I. Vernadskiy, USSR Academy of Sciences]

[Abstract] A description is given of the Lakshmi Plateau on Venus and of its setting, and an interpretation is given of the mechanism for formation of its structure. The Lakshmi Plateau occupies the western part of Ishtar Terra. It is a plain region with altitudes of about 3 km above the level of the plains below it. Its settling includes the Vesty Bench in the south and southwest, a region with a chaotic relief adjoining it in the south, and the massifs of the Akny and Freya mountains in the northwest and north. The periphery of Lakshmi's northern setting is made up of a gigantic ridge about 1,500 km long which separates Ishtar Terra from the northern plain. The plateau is in the shape of an irregular hexagon with smoothed-out angles and measures about 1,400 km across with a trapeziform protuberance in the north and a protuberance toward the east right to the foot of the Maxwell Mountains and measuring 800 km long and 200 km wide. The smooth surface is complicated by a series of structures, the principal ones being the Colette Depression, which is in the form of a gigantic shield volcano measuring about 600 km across and occupying almost the entire western half of the plateau, and the oval Sakajawea Depression located in the center of the eastern half of the plateau. The plateau's setting consists of concentrically arranged disconnected fold structures around its periphery. This structure is interpreted from the viewpoint of the subsurface horizontal flow of matter in the form of horizontally diverging asthenospheric flows and from the viewpoint of gravitational sliding. The setting's structures have formed on account of deformation of the more rigid lithosphere when it separated from the asthenospheric flow. It is concluded that the Lakshmi Plateau and its setting represent a unified structure formed by a unified process, as

indicated by its compactness and the conformability of its setting. The principal mechanism for the formation of the structure is based on the process of the rising of matter from the planet's interior to the surface and the horizontal flow of this matter accompanied by deformations of the folding type and/or the formation of tectonic plates. The spreading process was arrested at the stage of piling of the lithosphere into mountain-structure massifs, which was accompanied by separation of the asthenospheric flow. The lithospheric layer was about 10 km thick during formation of the structure.

Figures 10, references 4: 1 Russian, 3 Western.

[20-8831]

/8309

UDC: 551.24+523.4.42

STRUCTURE OF CENTRAL AND EASTERN PARTS OF ISHTAR TERRA AND SOME PROBLEMS OF TECTONICS OF VENUS

Moscow GEOTEKTONIKA in Russian No 4, Jul-Aug 86 (manuscript received 10 Nov 85) pp 42-53

[Article by A.T. Bazilevskiy, GEOKhI [Institute of Geochemistry and Analytical Chemistry imeni V.I. Vernadskiy], USSR Academy of Sciences]

[Abstract] A detailed description is given of the central and eastern parts of Ishtar Terra on Venus from the Maxwell Mountains to the east to the eastern end of Ishtar Terra, and the nature of this formation is assessed on the basis of the features described. The data employed are radar images, with resolution of 1 to 2 km, obtained from the Venus-15 and -16 spacecraft. Ishtar Terra is one of the two largest elevated regions on Venus, its area is approximately that of Australia, and it rises 2 to 10 km above the plains surrounding it. Ishtar Terra is a region with the extensive development of strong dislocations of an areal nature which are partly covered in its western half, i.e., the Lakshmi Plateau, with what is probably basaltic lava. A strip of strongly disjoint terrain with a predominance of subparallel and intersecting mountain ridges and the valleys which separate them extends from the Maxwell Mountains to the east all the way to the east end of Ishtar Terra. It is this strip which is described and analyzed. This area has been given the geographical name Tessara Fortunae. In going from the Maxwell Mountains to the east end, a gradual change takes place from submeridional meandering plicate ridges in the west to rectilinear intersecting disjunctive systems of the linked fault and sublatitudinal displacement type. These disjunctive systems have apparently transformed more ancient structures and the main axis of the stresses which created them is oriented primarily sublatitudinally. The younger structures in the west occupy a higher hypsometric position. The cause of the formation of the entire system could be a major asthenospheric flow which rose in the area of Lakshmi Plateau and the Maxwell Mountains and spread and sunk in the easterly direction entraining with it deformed blocks of the lithosphere. The system of intersecting ridges and valleys, i.e., the parquet or tessara, was formed by the stresses transmitted to the lithosphere by the flow moving below and the modification of earlier formed systems of subparallel ridges and valleys and possibly, in places, on account of the deformation of previously undeformed sections.

Figures 4, references 8: 5 Russian, 3 Western.

[20-8831]
/8309

UDC: 551.24+523.4.42

STRESSES ON SURFACE OF VENUS: STUDY OF VENUS-15, VENUS-16 DATA

Moscow GEOTEKTONIKA in Russian No 4, Jul-Aug 86 (manuscript received 10 Nov 85) pp 54-59

[Article by L.B. Ronka, Wayne State University, USA]

[Abstract] The radar images obtained by the Venus-15 and Venus-16 stations do not show clear signs of the presence of erosion and sedimentation processes on Venus with the radar equipment's resolution, of 1 to 2 km. Because of the absence of erosion, the tectonic deformations must have formed on the surface rather than in the planet's interior. One of the principal axes of stress ellipsoids must be perpendicular to the surface. The deformations visible in the Venus-15 and -16 images are used to determine the orientations of stress ellipsoids for various sections of the Maxwell Mountains and the Northern Parquet. The ellipsoids, and their orientations, constructed for linked faults are shown. Linked faults are systems of faults which intersect at other than right angles and in which one system does not intersect the other in tandem. Linked faults are found in some sections of linear structures east of the Maxwell Mountains and on the Northern Parquet. In both the Maxwell Mountains and a part of the Northern Parquet the principal direction of stresses is latitudinal, but in the Maxwell Mountains the interstitial stresses are oriented horizontally in the meridional direction and on the Northern Parquet the interstitial stress vector is vertical. On the plains west of the Maxwell Mountains there is a system of open carved crevasses extending to the south. On the basis of stress ellipsoids, these crevasses are interpreted as tension fractures and faults whose formation was accompanied by the turning of the ellipsoid in the southerly direction. One possible interpretation is given of the structure of the Maxwell Mountains and the depression to the south of them. It is suggested that the latitudinal stresses here were caused by upheaval of the Maxwell Mountains and upthrusts, the origin of a shearing zone, and the formation of a depression. The depression is probably filled with lava.

Figures 6, references 7: 2 Russian, 5 Western.

[20-8831]
/8309

UDC: 551.24+523.4.42

PARQUET: REGIONS OF AREAL PLASTIC DISLOCATIONS

Moscow GEOTEKTONIKA in Russian No 4, Jul-Aug 86 (manuscript received 10 Nov 86) pp 60-76

[Article by A.L. Sukhanov, Geology Institute, USSR Academy of Sciences]

[Text] The extensive gently sloping uplands of the northern hemisphere of Venus are covered by frequent intersecting areal dislocations which are called a parquet because of their appearance on radar images. They occupy about $9 \cdot 10^6$ km^2 of the territory photographed. They are represented by several large isometric sections measuring 500,000 to two million square kilometers each and by individual small mesas among lava fields. A parquet is formed generally of two or three systems of intersecting ridges and valleys with a typical width of 5 or 10 and up to 20 km and from a few dozen to a few hundred kilometers long. They form orthogonal, diagonal and V-shaped patterns which differ both in size and structure from the fold-and-fault setting of the Lakshmi Plateau and the areas of linear structures on the plains. The patterns differ widely among themselves and they cover vast territories. A description is given of the principal regions of parquet development, from chaotic irregular sections to sections where the structures display a preferred orientation. The following regions are discussed: the region between the plains of Atalanta and Niobe, the Tellura region, the Southern Parquet of Ishtar Terra, the Tethys region, the "horseshoe" parquet, and the Northern Parquet of Ishtar Terra. The abundance of parquet structures is discussed, as well as their relationships to lava and zones of linear dislocation, the mechanism for the formation of parquets, and the place of the parquet in the tectonic picture. Grabens and regions of tension are seen in the inner sections of parquets and tonguelike flow structures on their peripheries. Parquets formed after the start of the formation of lava plains but have been covered by very young lava. Parquets apparently originated partly on account of dragging of blocks of the crust by asthenospheric flows and partly by the gravitational sliding of heated blocks of the crust with the partial melting of their bases. These upheavals possibly occupy in the tectonics of Venus the place of rift systems on the Earth. It is possible, therefore, that the concept of plate tectonics cannot be applied to Venus.

Figures 9, references 20: 12 Russian, 8 Western.

[20-8831]

/8309

UDC: 551.24+523.4.42

STRUCTURAL ENSEMBLES OF NORTHERN BELT OF DEFORMATIONS ON VENUS AND POSSIBLE MECHANISMS FOR THEIR FORMATION

Moscow GEOTEKTONIKA in Russian No 4, Jul-Aug 86 (manuscript received 10 Nov 85) pp 77-87

[Article by M.S. Markov, Geology Institute, USSR Academy of Sciences]

[Text] The belt of tectonic deformations in the northern hemisphere of Venus represents a large zone of horizontal displacements of the matter of the crust, within whose limits it is possible to interpret clearly the existence of areas of faults, thrusts, inverted folds or tectonic plates united into a single structural ensemble. These structural ensembles are discussed on the basis of the data of radar images obtained from the Venus-15 and -16 spacecraft. It is shown that they consist of regions of compression oriented submeridionally, fault regions stretching in a sublatitudinal direction, and individual slightly deformed blocks. Compression structures are found in the Akny and Maxwell Mountains, and fault structures at the northwest end of the Akny Mountains, the Ut Bench, the Tethys region, the Southern Parquet of Ishtar Terra, and the Tellura region. Compression structures are represented most clearly on Venus in the Akny and Maxwell Mountains and are in the form of a system of extended linear ridges and the valleys separating them, bordering the Lakshmi Plateau in the east and west. Fault structures are most widespread in the sublatitudinal belt of tectonic deformations and differ in various sections. This latter fact can be explained by different extents of displacement, different thicknesses of the lithosphere, or different degrees of heating of the crust and, accordingly, by various degrees of plasticity of the crust. All these facts account for differences in the morphology of deformations in fault zones. Submeridional dislocations are represented by the regions of compression, which are expressed either as thrusts, such as in the eastern part of Ishtar Terra and the Tellura region, or as tectonic plates or systems of inverted folds, such as in the Akny and Maxwell Mountains. The entire belt is thus an extensive area of separation whose structural ensembles are associated with the general

movement of masses in the sublatitudinal direction. It is assumed that this motion took place principally in an easterly direction. The structural ensembles are complicated by the effect of gravitational sliding, most likely associated with the relatively small thickness of the lithosphere and the greater degree of heating of the crust and its lower viscosity. The types of deformations of the lithosphere of Venus are apparently similar to the deformations of the Early Precambrian zone of the earth.

Figures 3, references 10: 4 Russian, 6 Western.

[20-8831]

/8309

UDC: 535.37:523.42

ANALYSIS OF CONDITIONS FOR FORMATION OF VENUSIAN NIGHTTIME IONOSPHERE DETERMINED FROM RADIO ECLIPSE DATA

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 4 Sep 85) pp 620-630

[Article by A.L. Gavrik, I.K. Osmolovskiy and L.N. Samoznayev]

[Abstract] A study was made of formation of the Venusian nighttime ionosphere with two ionization maxima in conformity to the mechanism proposed by I.K. Osmolovskiy, et al, in DOKL. AN SSSR, Vol 276, No 5, p 325, 1984 and making use of all data collected by the "Venera-9, -10" satellites characterizing ionospheric behavior at the time of low solar activity. In addition to the ionization of atomic and molecular oxygen, allowance was also made for the influence of the NO^+ ion detected by the "Pioneer-Venus" probe. The three-component model (O^+, O_2^+, NO^+) used is fully described. It was assumed that the source of primary ions was O^+ plasma flowing from the daytime to the nighttime side and diffusing downward. The model, provided that certain assumptions are valid, explains the behavior of the vertical electron concentration profiles obtained by the radio eclipse method. It was found that the variability of the nighttime ionosphere is attributable to variations in temperature of plasma and the neutral component, density of the flux of primary ions and content of neutral components in the planetary atmosphere. The dependence of the temperature of plasma and molecules on altitude with a non-monotonic character and the occurrence of local heating at altitudes 130-140 km are responsible for the two electron concentration maxima at altitudes 12-22 km apart and the small scale heights and half-thicknesses of ionized layers. The small vertical extent of the main body of the ionosphere in years of low solar activity is attributable to a marked increase in plasma temperature above the upper ionization maximum. Atmospheric temperature, which is lower during a period of low solar activity than during high activity, determines the position of the ionization maxima.

Figures 3, references 26: 10 Russian, 16 Western.

5303/8309
CSO: 1866/4

INTERPLANETARY SCIENCES

UDC: 523.64

STUDY OF HALLEY'S COMET WITH ULTRAVIOLET TELESCOPE OF 'ASTRON' ASTROPHYSICAL STATION IN DECEMBER 1985

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86
(manuscript received 27 Feb 86) pp 471-474

[Article by A.A. Voyarchuk, A.M. Zvereva, R.S. Kremnev, P.P. Petrov, K.G. Sukharov, N.S. Chernikh, and A.I. Sheykhet]

[Abstract] In 1985 as comet Halley approached the sun it was observed with an ultraviolet telescope of the "Astron" astrophysical station. Three sessions of observation of the head of the comet were held, on 3, 13 and 23 December; teo sessions of observation of the remote areas of the head and tail of the comet were held on 14 and 17 December. The spectra obtained near the nucleus of the comet are presented, along with a photograph of the comet showing areas from which the spectra were taken. The relative intensities of emission lines did not change from session to session. The major spectral feature was emission lines of hydroxyl, which contained some 75 percent of the radiation of the comet in the 1500-3500 A area. The spectrum also contained radiation in the lines of NH, CS, C_2, CO_2^+ and C^+. Continuous radiation was observed at $\lambda > 2700$ A, resulting from the reflection and scattering of solar radiation on dust particles in the head of the comet.

Figures 2, references 2: 1 Russian, 1 Western.

6508/8309
CSO: 1866/141

YEAR-LONG HYPOKINESIA EXPERIMENT IN PROGRESS

Daily Life of Particpants Described

Moscow KOMSOMOLSKAYA PRAVDA in Russian 10 Aug 86 p 4

[Article by L. Repin: "Test Subjects"]

[Text] These ten men have been living in a topsy-turvy world for four months now. For us this is an ordinary world. For them it is completely different and everything occurs as if in another dimension. Because these months they are living in a horizontal position. It is even categorically forbidden that they sit up...

***

Such are the conditions of the experiment. The ten volunteer test subjects became part of this very difficult test for the sake of those who for long months will work in orbit distant from the earth, for those -- and the time will come for this -- who will leave the planet for years, blazing the road to other worlds. But the experiment was not organized for the sake of cosmonauts alone, but for the sake of you and me.

Let's take a fleeting glance at ourselves from a distance. In transportation facilities, on the way to work, we sit or stand, but in any case we are in a state of hypokinesia -- relative immobility. And at work we also sit or stand.

And at home? We again sit! And we ourselves do not note how this state has become the ordinary thing for us and is more natural, for example, than walking or running. However, we pay a price for this... Immobility forces us to pay a high price for our love of this. The price is health. Cardiovascular diseases, diseases of the internal organs, muscular atrophy and a great many other ailments for which we seek an explanation somewhere outside ourselves, but the reasons lie within ourselves, in our life style. Indeed, Horace -- the poet and great sage -- stated: "If you do not run when healthy, you will run when you fall ill." Judging from everything, he had in mind running to doctors.

But these are general considerations. A view from on high. In actuality, for the time being we know little about the influence of a sedentary life style on our bodies. In reality, even doctors treating patients who have been confined to bed for months or even years by no means always take into account the effect

of hypokinesia on their patients. Only recently has it been recommended that those who have experienced heart attacks should move about, whereas earlier this was simply not allowed! The same applies to those who have had an operation. It goes without saying that by no means everyone who has had an operation is allowed to walk at once, but such a tendency, a reevaluation of established points of view in medicine today, unquestionably has begun.

So, we still have learned too little concerning the entire degree of the effect of hypokinesia on our bodies. Such experiments as the one described here are therefore especially important. It is by no means the first. Planned, stubborn research in this direction in medicine has already been carried out for more than 20 years both in our country and abroad. But with respect to the planned duration (it is proposed that it will last up to a year) and the volume of research, as well as the scientific level of the research and technical outfitting, the Soviet experiment, to be sure, has no equal. A half-year experiment was successfully completed in our country, but now a half-year of presence in a state of hypokinesia is short: Soviet cosmonauts have already lived for 237 days in a state of weightlessness. The requirements of life are outpacing experimentation. For the time being.

Boris Morukov, candidate of medical sciences, the responsible physician in this experiment, senior scientific specialist at the Biomedical Problems Institute, USSR Ministry of Health, is the man who can be called the 11th participant, and that is exactly the way his test subjects view him. He tells of the structure, if we may express it so, of the experiment. The test subjects were divided into two groups of five men each. They are confined in different wards. In the first stage one group of five simply lies in bed, and that's it. It goes without saying that analyses of the examinations and all manner of tests leave them little time. The other five receive prophylactic therapy helping in the battle against the influence of hypokinesia: drugs, special-purpose vitamins, and in addition, each day the subjects in this group perform physical exercises like cosmonauts aboard a ship and using the same equipment.

Resounding, measured footsteps can be heard from the corridor in the ward where we are talking. I thought that if someone took it into their head to try on knight's armor and try to run by in it, the sound of the footsteps would be very much the same. Morukov, looking at me attentively, then at his watch, said: "Right now they are training. Let's go and take a look."

At that minute it came to me that they have a topsy-turvy world. Here were two lying on their backs, studded with telemetric sensors and enshrouded in straps and suspensions hanging from a metal structure resembling the framework of some fantastic structure within which they were confined. By these broad, well-devised straps, thrown across the shoulders of the test subjects, they were drawn to a vertically standing track with a force equal to their weight. The feet, clad in running shoes, in measured steps ran heavily along the moving track; indeed, they had to overcome not only the force of gravity, but also the elastic forces of these steel springs and rubber strands. Running along a vertical wall. I had never had an opportunity to see such a thing...

They entered the experiment early in the spring when dirty patches of snow still remained here and there on the lawns and the trees were still leafless,

like in the winter. Now, through the wide-open window, came the rustle of poplar leaves, the fresh smells of summer which these five breathed in with delight. They hopelessly dream of strolling through the grass and touching their hands to the green branches, but they will have to wait a long time for this.

Now it is the time for rest for those who have remained in the ward and each is busy with something of his own liking. One is wearing headphones so that no one will be disturbed while he listens to music, another is reading and still another is writing something in a notebook, very concentrated, sometimes smiling at some thoughts.

The first man with whom I became acquainted here was Sergey Kopanev. He was 34 years old, a physician. He celebrated his birthday during the course of the experiment. The roses and sweet williams brought by the doctors and nurses then remained for a long time on his night table.

Sergey is an experienced test subject and participated in many experiments. I asked what had drawn him into such a long and difficult test. He answered: "You understand, I wanted to learn what I can. I knew that it would be difficult, not only physically, but also psychologically. Imagine a situation if we, all of us in this ward, did not get along with one another?"

The life of Sergey is now unusual in many respects, and not only because he and his comrades have an unusual life style, but because during the time of the experiment he has continued to work on his dissertation. In July he was visited by the authoritative examination commission, which after a prolonged interview awarded him a well-deserved "excellent" in his field of specialization.

Vladimir Sitnichenko was 40 years old. Prior to the experiment he worked as a senior technician. He was also accustomed to participating in other experiments; he was raised to an altitude of 11,000 meters in a pressure chamber. He came to this experiment, as he himself expressed it with a smile, "more out of habit." It seems to me that this is not exactly true. There was nothing of habit involved: he simply could not live without adventure. That is more likely.

What was the most difficult? To make it through to the end. And hoping everything would go off smoothly. He was a level-headed and calm person who read a lot and his spirits were lifted when he listened to popular music. And once a week, to be sure, he was allowed to call home. These infrequent and brief telephone "meetings" with his wife and son Andrushya did a great deal to maintain his spirits. When I departed he politely waved his hand and immediately picked up an open book which was lying on his chest. In my opinion he was not one of those who can simply waste time.

Igor Poyarkov, 35 years old. Mechanical engineer. Prepared carefully for the experiment for a long time. He understood that it would be very, very difficult and that success would be dependent primarily on he himself, how he had morally and psychologically prepared himself. "Well, how goes it?" I ask. "I guess that everything is going OK for the time being..." But it seemed to

me that something was nevertheless bothering Igor. I hesitated for the moment, to ask him or not to ask him, but he himself told me about it.

He allowed me to share this important family secret: at that very moment he was awaiting an addition to the family. If a son was born, he would probably be called Ilya, whereas if it was a daughter they would call her Nastenka.

Aleksandr Yudin, age 37, marked his birthday during the experiment, in June. Everyone was treated with cherries and his mood was excellent. For some time he even forgot that only part of the job was completed and that the most difficult part was still ahead. The "chief" (as they have named Boris Morukov) arrived with congratulations and everything possible was done in order that this day be a joyous occasion not only for Aleksandr, but also for all his comrades.

So we found out that during the last 1 1/2 years Aleksandr has been living alone, without his family. Olga, his wife, and the child Serezhka, 1 1/2 years old, went off to her parents in Leningrad. It was difficult for her alone and now -- another year of forced separation... Yudin thinks about this a lot, and speaking honestly, not without alarm. It seems to me that anyone can understand this.

Aleksandr told me that it was the beginning which was most difficult for him. He became part of the group with difficulty, was too demanding on others, as he himself acknowledges, but then he learned to understand them better, became more condescending toward his comrades and became more demanding on himself. Only now, he said, do you begin to appreciate what ordinary life is like, together with those who are near and dear to you...

In this new day-to-day life, Aleksandr experienced additional difficulties due to the fact that he was a smoker. He was the only one among the five who smoked. Understandably, smoking is not allowed in the ward and therefore once a day a small excursion was arranged for him into the corridor. But he made up his mind and completely abandoned smoking -- as was altogether appropriate.

But the greatest joy for all, rest and distraction, although they returned weary, was a trip to Moscow to the cardiological center for examination. Whirling, swaying, the ambulance sped through intersections where the flow of traffic had been stopped, and only through a corner of the window could they catch a glimpse of fragments of episodes of life in the large city and hear its "breathing."

I foresee a question: so what's difficult about this -- lying in bed all day? After all, there are plenty of sick people who are forced to occupy such a position for months and even years...

Yes, in actuality there are people who are confined to bed for a long time. But their bodies, the course of all physiological processes, is adapted to the unusual state of man. Yes, and psychologically they are prepared for it: inevitability forces that it be dealt with by patience and respect. But these are young, absolutely healthy people, who have gone through the test of

exceedingly rigorous requirements, the most scrupulous selection on the basis of the strictest criteria -- like cosmonauts -- and here they are forced to tolerate immobility.

Lying in bed for a long time is very difficult for a healthy man. As indicated by the preceding experiments, changes develop in the cardiovascular system, different internal organs experience a serious testing and there is danger of of muscular atrophy... It is for these reasons that this experiment was organized and that these ten strong, and one would very much like to say, courageous men, with confidence and without doubts, have dedicated themselves to science.

And precisely because such an experiment is necessary to science the physicians and scientists are working alongside the test subjects. We discussed the difficulties and scientific objectives of the experiment with A. I. Grigoryev, doctor of medical sciences, first deputy director of the institute, member of the International Academy of Astronautics. Anatoliy Ivanovich, by nature of his work, has already for many years been concerned with the medical support of space flights. Accordingly, he clearly sees and understands the close relationship between terrestrial and space research.

In actuality, the different types of research have much in common. In a hypokinesia experiment the conditions of weightlessness are simulated quite well in physiological respects. Both in space and on earth a great volume of blood is accumulated in the neighborhood of the chest and the abdomen -- this in an antiorthostatic position when the feet are above the head. "We felt the need for such research long ago," says A. I. Grigoryev, "especially after the first prolonged flights, when for the first time, as a matter of fact, deviations appeared in the human cardiovascular system, as well as in the support-motor system. Later it was possible to develop a number of prophylactic measures for contending with weightlessness, the basis for which was physical exercises in special trainers. It was extremely effective, but required from the cosmonauts not less than two hours of exercises each day. These hours are lost for science, for rest... and we are working on an improvement of this complex, we are seeking new means which would make it possible to shorten this time as much as possible."

I asked the scientist a question which is very important for cosmonauts who for a long time have been living in orbit: in a state of weightlessness calcium is actively excreted from the human body and this, as is well known, is fraught with danger for the entire bone-muscular system. Does something like this occur in an experiment with prolonged hypokinesia?

In fact, it does occur. The scientist cited figures like this: every month about 5 g of calcium are excreted from the body of a test subject. To be sure, this is not a great deal if it is taken into account that each of us is the possessor of 1200 g of calcium. But this is a great deal if the experiment lasts for many months...

"Incidentally," adds A. I. Grigoryev, "this is our fundamental task: by improving preventive means to interdict the negative influence of weightlessness on the human body."

...You now know a little about four of them (one wished to remain "out of the picture") and you will probably agree with me when I say that it is remarkable that alongside us are people like they, ready to endure privations if somehow this will be of benefit to someone. Assume it will be easier for someone later. Not now and not immediately. But sometime it will surely become easier, of this they have no doubt. This is precisely the aspect of the experiment on which they all agreed.

We will meet with them as they complete the first half of the experiment.

Visit to Hypokinesia Subjects

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 20 Aug 86 p 4

[Article by G. Lomanov: "Whither Fly the 'Terrestrial Starships'?"]

[Text] I hesitated in front of the door with a placard reading "Entry Forbidden." Boris Vladimirovich Morukov, candidate of medical sciences, smiled involuntarily: "Take heart, you are not going to float away, we cannot reproduce weightlessness, unfortunately, we cannot create a world without gravity and it is necessary to simulate it."

And we entered the living compartment of the "terrestrial starship," an ordinary hospital ward...

The experiment began in April of this year. Ten completely healthy males at the height of their powers, confined to bed, tilted at an angle of 5° to the headboard. The tipping is necessary in order to bring about blood redistribution in the body, as happens in space.

The test subjects are allowed to read, to listen to music, to make something and to write letters home. It is even possible to smoke in bed, provided that the neighbors do not complain. The organizers of the experiment, scientists of the Biomedical Problems Institute, USSR Ministry of Health, were condescending in many things. But in the most important things they have remained uncompromisingly firm: the test subjects not only cannot get up, but even raise up in bed. To be sure, except for those days when some physiological tests are made.

In these wards it is not exactly snug, but it is entirely comfortable. And I involuntarily recalled how I prepared a feature article on the behavior of people under extremal conditions. I thought about the test subjects who for a half-month lived in snow caves or sat among sand dunes under the blazing sun in the desert, with 40° heat and with a scanty water supply. As if guessing my thoughts, one of the experiment participants noted ironically:

"Well, they bring us breakfast, lunch and dinner in bed, like at a fashionable resort. Only, you know, this is no rest home. It is extremely difficult for an active man, accustomed to freedom of movements, to lie on his back for months. This is not rest, but real work. I think that psychologically getting ready for it is no easier than for a cosmonaut to ready himself for a prolonged expedition."

And yet, to compare a clinic with a spaceship, to speak of a "terrestrial flight," is this not too bold a metaphor ?

"Stretching it a bit, to be sure, but there is more than a little similarity," responds Boris Morukov. "Prolonged hypokinesia, speaking more simply, limited motor activity, in a number of body systems causes approximately the same changes as weightlessness. Even before the flight of Yuriy Gagarin scientists postulated that long travels in the universe without gravity can result in shifts in metabolism, in the composition and structure of bone tissue. Prolonged space flights confirmed the hypothesis: in a state of weightlessness man experiences atrophy of muscles, develops a negative calcium and phosphorus balance and suffers a decrease in bone strength. Soviet scientists have developed a complex of prophylactic measures making it possible to increase the duration of stays in orbit to eight months. However, space flights are constantly raising new questions, answers to which to a great extent will be given by terrestrial research.

The present experiment is the next in a whole series. Groups of researchers have already "flown" both for four months and for a half-year. Now scientists plan to leave this record behind; it is proposed that the new crew will live under conditions of extremely severe hypokinesia for about a year!

However, the group can be called "new" only with some reservations because some of the test subjects have already participated in such experiments. And there are no complaints about health.

I arrived at the institute when the test subjects had passed the four-month mark. This was the day of a thorough medical examination. Senior scientific specialist V. Kozlov began it with the registry of circulatory functions. Then the test subjects were wheeled into the "shop" of A. Kotovskaya, to the centrifuge. Adilya Rovgatovna is a person well known in cosmonautics and long ago she spun Gagarin and his comrades on this "merry-go-round," checking the tolerance of future cosmonauts to accelerations. And in her doctoral dissertation, written on the basis of model experiments, she cited an interesting and unexpected fact: at the end of a 100-day "terrestrial flight" the subjects tolerate accelerations no worse than during the first two or three weeks of hypokinesia. A paradox, it would seem, but the human body has great reserves. The swiftly rotating centrifuge gives the same accelerations as the cosmonauts experience during a landing. But this does not end the examination "conveyor belt": the subjects are taken from one laboratory to another. Here a man, disaccustomed to a vertical pose, stands motionless and the physicians carry out physiological tests at this time. Incidentally, not all have the strength to stand there for only 20 minutes. Then the treadmill, a moving track on which the "cosmonaut" takes his first steps after "landing." In short, in the experiment there is simulation of all the stages in real flight. So would it not be simpler to study all this directly in orbit? Would not the results be more precise?

"That is a difficult question," responds Anatoliy Ivanovich Grigoryev, scientific director of the experiment, first deputy director of the institute, doctor of medical sciences. "It goes without saying that before and after a

space expedition the crews are thoroughly examined, during the flight they undergo many medical investigations, and the doctors attentively check their sense of well-being. But to make detailed studies in orbit, for example, of changes in the support-motor system, is still not yet possible. Now this is done indirectly: the cosmonauts periodically measure the volume of the shin and hip, which to a definite degree makes it possible to judge the degree of muscular atrophy and the rates of bone tissue demineralization. On the ground we make dynamic studies of these processes by the most modern methods, ranging from ultrasonic diagnosis to computer tomography, and regularly carry out various kinds of biochemical tests, with detailed study of the peculiarities of hormonal regulation. Unfortunately, for the time being we cannot carry out such an extensive research program in space."

"In fact, in order to do that you would have to launch your clinic into space."

"And not just the clinic. Cooperating with us are specialists of the All-Union Cardiological Scientific Center, the Central Scientific Research Institute of Traumatology and Orthopedics, the Scientific Research Institute of Medical Radiology and other scientific institutions."

"In similar experiments there has been the most scrupulous study of the interrelationship of all kinds of metabolism and functioning of the most important body systems. Yes, we know well that in spaceflight the muscles are weakened, the functions of the digestive system change and the bone tissue loses calcium. All this has been confirmed more than once by post-flight crew examinations. But how is body balance impaired and in what stages? What prophylactic measures are required in order to reduce the undesirable shifts to a minimum? The enormous volume of information received in the simulation experiments is making it possible to clarify the finest nuances of complex processes. And this, in the long run, is helping to answer the main question in space biology and medicine: to what extent is it possible to work in a state of weightlessness without damage to the health?"

5303
CSO: 1866/7

IZVESTIYA COMMENTARY ON HYPOKINESIA EXPERIMENT

Moscow IZVESTIYA in Russian 26 Sep 86 p 6

[Report by A. Ivakhnov, special correspondent to IZVESTIYA: "A Model of Weightlessness: New Research in the Human Organism's Resources During Prolonged Flight"]

[Text] In the laboratory ward two calendars with big colored pictures hang above a hospital bed. On the right is a snow white sailboat cutting through the sea's smooth surface. The calendar's owner, engineer Igor Payarkov is an inveterate yachtsman. Glancing at the sails filled out by the wind, he is mentally carried away to where the salty wind smells of seaweed and when there is a boundless expanse from horizon to horizon. While the calendar on the left is, in his words, an analogy for his present existence. A garden of Eden, a well-tended bird on a branch, nearby, spring water, and choice kernels of grain in dishes. And...a gold chain forming a ring around a leg. Everything is there except freedom of movement....

My partner in conversation, like all the others in this ward, as well as in two adjacent wards--there are only ten of them--have already spent several months "confined" to their beds. They wash, shave, take their meals, and do everything else in a lying position. In this position they are taken to wash, and from the bath they are transferred immediately to mobile beds.

They aren't sick at all, if they had gone after the role of cosmonaut, the sternest medical commission wouldn't have been able to find any objections to them. They, by the way, have also passed through such a commission, and many of the "examiners" in white coats were from among those who select the cosmonauts. They picked out these ten from about fifty candidates.

Maintaining a lying position has been their work for many months; it has a direct bearing on space flights.

"At the very beginning of learning to handle near-Earth space," said A. Grigoryev, the scientist in charge of the experiment, doctor of medical sciences, and the first deputy director of the Biomedical Problems Institute of the USSR Ministry of Health, "no one, including scientists, knew whether or not man could live and work in weightlessness for a prolonged period of time. Participants in the first space flights told how right after getting into orbit, blood would rush to their heads. With even more prolonged periods of time spent in flight it became clear that these sensations disappear after a few days: one's general state becomes good, one works readily, one couldn't wish for anything better."

But here other surprises were concealed. The longer the durations of space expeditions became, the more difficult it was for the astronauts later, on Earth, to get unaccustomed again to weightlessness and adapt to the conditions of the Earth's gravitation. In the hours after landing, their arms and legs felt like lead so that motion required great efforts. Many days would pass before the astronauts fully restored their ability to carry on their usual way of life. The question even arose that perhaps there is some boundary line to the duration of life in weightlessness, which, if once crossed, the human organism would free itself from the planet's gravitational forces?

In the process of directed research, it was established that many physiological changes that occur in weightlessness are reproduced when a person lies in a position with his feet raised slightly higher than his head.

The first such research—it lasted a few weeks, that was all that was required then--helped a lot to understand the mechanisms which lead to the changes in the cardiovascular system and to the motor-support apparatus of the cosmonauts under the influence of weightlessness. This resulted in the creation of a set of preventive measures: on orbital stations there appeared a stationary bicycle, a "running track," and the vacuum suit "Chibis." The crew members were given strict instructions to engage in active physical exercise. This had satisfactory results: in 1975 P. Klimuk and V. Sevastyanov, upon their return from a record-setting flight of 2 months, were able to walk from the landing vehicle by themselves. About 10 years ago research was conducted with participants who remained in a lying position for half a year. This had great merit, for space flights became of many months' duration. "Thanks, thanks very much to medicine!" said L. Kizim after returning recently from his third mission in orbit, having spent a cumulative total of more than a year in space. Undoubtedly he had in mind the volunteer participants who paved the way for cosmonauts in laboratories on earth.

...From foot to head, the beds are inclined at a five degree angle, and there are no pillows. It is not advisable to raise one's head.

"Surely it's uncomfortable to lie like this?"

"At first we suffered a great deal. However you positioned yourself, everything was uncomfortable, something always interfered. There was a ringing in your ears and your temples felt as if little hammers were banging. But by about the twentieth day there was a feeling of relief, and a sense of comfort would come over you. Now this is our normal condition."

"What do you eat?"

"An 'earthly' dinner, on plates. As a rule, it's very tasty: the cooks here are excellent. For breakfast and supper--'space' food: stuff from tubes and cans. All that's also very tasty, but often repetitive and so we're tired of it. But we have to eat everything down to the last bit--this is a condition of the experiment. Medical doctors are analyzing the quantity and composition of substances as they enter and exit the organism."

"What kind of contact do you have with your family?"

"In the evenings we're sometimes permitted to talk with them on the telephone, but not too often..."

This requires an explanation. In selecting the participants, one of the decisive questions concerned the family's well-being. What kind of relations the family had and whether the wife was prepared for such a lengthy separation. Medical doctors take a guarded approach to these discussions on the telephone because some conversation could destroy someone's mood for a long time and even lead to someone's elimination from the experiment.

"I have no one to call," said Igor sadly. "My wife has gone to Kirov to live with her parents. We're expecting a child, and it would be hard on her to be here without me..."

"What do you do to keep busy here? It must be boring to lie like this?"

"When we were packing up, everyone had some sort of plan for themselves: to reread a lot of imaginative literature, to study a foreign language to perfection. If one can speak frankly, these plans are not being carried out. Perhaps the head doesn't work as well in such a position, laziness overtakes us, but serious books somehow don't get read, only detective and historical novels--they've got all sorts of adventures.... However, under these conditions, it's possible to do something responsible. Like what Seryozha Kopanev does. He's a doctor and for several years he took part in getting the astronauts ready. He could be among the medical doctors who are now working with us, but he chose to experiment on himself. And at the same time he continues to work on a dissertation. He orders scientific works from the library, reads a lot, and writes. Recently he passed an exam that qualified him for the candidate's degree. The processors came to see him in the ward and he answered them from his lying position.

"How else do we keep busy? We watch television--whatever comes on, it's still a connection to the outside world. During the first few days it was on almost from morning till night. But, as you know, many programs repeat, and there are few interesting ones to boot. Now we turn it on only for the news program "Time" and when there are films....

"Now, the medical doctors don't allow us to get bored: the entire first part of the day is taken up with analyses, examinations, and physical training. After dinner we sit around and talk, recall interesting stories of things that have happened to us. Sometimes we sing. Or we simply lie around, think--this is a rare opportunity to analyze our lives.

"By the way, these many long weeks in a small group have taught each one of us something. We've become more tolerant, perhaps more attentive to others. When we were being selected, the doctors of course thought about our psychological compatibility. However, at first there was a situation of conflict with

one another here and each one felt offended by the others. But gradually we learned to give in to one another, to respect a colleague's opinion. When from this position you recall your former interactions with people before the experiment--with our wives--it's sometimes frustrating: in many cases we would have acted differently now. So that in the plan of developing our character, the experiment has done us good."

After spending time with the participants, I met once more with the experiment's director, A. Grigoryev.

"The experiment's participants," he relates, "are divided into two groups. The first five from the very beginning have been taking medicines, do gymnastics, turn the peddles of a stationary bicycle--also in a lying position, and train on a "running track." We have a special one. The participant lies in a swing bolster which is pulled toward the "track" by spring braces with a force equal to his weight. The exercises include walking, running, and jumping--all this till he works up an abundant sweat and gets tired. We also have a device that simulates working out with weights. This is a difficult physical work-out and it's done every day, for about 2 hours. In contrast, the second group, didn't do any of this for 4 months, taking up the activities only on the hundred and twenty-first day. When the first 4-month period had expired, both groups underwent examinations which were no less painstaking than during the original selection process. They were transported to another building in the institute where they were rotated on a centrifuge, laid down on special tables which were then put into a vertical position, and they had to stand on their feet for twenty minutes without shifting at all. Many other tests were carried out to check their ability to bear loads. Their blood was tested, the condition of the muscle and bone tissue was evaluated along with the functioning of their digestive, respiratory, cardiovascular, and other systems.

The same thorough examinations will be done on the 240th day, and then at the conclusion of the experiment. All the data obtained is now being analyzed and compared. It's too early to talk about conclusions, though one thing can be said: space medicine will obtain very rich material. We owe enormous gratitude to the participants: their work, without any reservations, must be called a heroic feat.

...Today access to the laboratory wards is limited only to the doctors and nurses who are involved in the research. The path there has been closed to outsiders, including journalists until the next stage of the experiment has been completed. I saw a young woman knocking at the door of the laboratory, the wife, apparently, of one of the participants. Her loved one, without suspecting, at this point was lying quite close to her. The door opened, there was a short conversation with a person in a white coat, a package passed from one set of hands to another--judging from everything, they were books, and the woman, looking back at the windows, head for the exit from the confines of the institute. No, he won't glance out the window, and they won't see one another soon.

Recently a colleague called me:

"Do you remember Igor, you know, the one who had the calendar with a bird hanging above his bed? A telegram has arrived at the institute: he's had a son....

Life goes on--children are born, new crew members prepare for flights, and on blueprints there are the outlines of future interplanetary space ships. Perhaps, Igor's son will be the very one to set out on a journey in such a ship. On a journey for which Igor Poyarkov and his colleagues are paving the way.

13085/8309
CSO: 1866/11

HYPOKINESIA EXPERIMENT PASSES HALFWAY POINT

Moscow KOMSOMOLSKAYA PRAVDA in Russian 5 Oct 86 p 4

[Article by special correspondent L. Repin: "Test Subjects"]

> [Text] Six months have passed since the start of this unique experiment on simulated weightlessness in terrestrial conditions. We reacquaint ourselves with those who have dedicated themselves to the service of science.

--Moscow--Half a year past, half a year to go. It is difficult to decide which is harder--these past six months or those to come. Each of the parties involved has his own opinion. The only thing they agree on is that the remaining term becomes less with each new day. The thought is somewhat comforting.

Has anything new occurred in the past two months since our meeting, while each of us has been occupied with our own affairs--punctually going to work, storming the public transit during the rush hour, or relaxing during this best of all seasons, but they have just been lying around under the watchful, concerned gaze of the physicians.

Something has indeed happened. A son was born to Igor Poyarkov, and as promised before he ever saw the light, named Ilya. The birth took place without event, and the happy father is joyous. His fellow experimental subjects, as well as all the attending personnel, loudly and gladly congratulated him. People who for the most part had not previously known each other had learned to share common joy and common grief. This is not to suggest that there is not discord at times. We should not imagine some idyllic setting as prevails during the autumn season on the beaches of the warm waters in the subtropics.

And yet the very fact that they have fitted in, become more tolerant and obliging, understanding and forgiving of their comrade's weaknesses, habits which were previously disagreeable--all of this should surely be considered one of the major results of the first half year of their joint existence in the experiment. I questioned each of them about this and always got the same answer. I cannot doubt their sincerity in this regard.

Such is the mental outcome of the experiment over the long haul. I believe its significance is entirely comparable to a scientific result. For only as a unit, in the expectation of merging both parties--experimentalist and test subject--can we count on success in so arduous an enterprise.

The last time I was not able to discuss all the test subjects, and so now I shall continue to introduce them.

Boris Apenin is 27 years old. Despite the obvious youth in his face, his accomplishments are many. His son Sasha is 3½ years old, his daughter Irochka is 7. Initially, Boris was very concerned about her, wondering how she would get through first grade without him around, but it turns out she is doing quite well. She is receiving her first "A's" in her life, which will soothe her anxious father.

By education, Boris is a lawyer, a graduate of the institute, with considerable experience as a criminal prosecutor. He loves his work and intends to return to it after the experiment.

Apenin is a true athlete, a master of "sambo" [self-defense without weapons] and judo. He is used to great physical exertion, but even he is now experiencing difficulty. In fact, he and three other comrades have been assigned to the group performing an increased physical workload under simulated weightlessness. But this has not hindered him from getting to like treadmill running, except that it is in the supine position. It is especially pleasant to run to the accompaniment of A. Pugacheva's singing.

I should add that he looks forward to the end of the experiment with special interest: this will be Irochka's birthday.

There are two test subjects in this ward. Along with Boris, there is Yevgeniy Gorin. He is 42 years old. His daughter Veronika has completed secondary school and is now working as a nurse. Both father and daughter dream of the time when Veronika will become a doctor. Or more accurately, a specialist in space medicine. Yevgeniy himself is a specialist in control systems. As you can see, they have a definite family approach to the solving of space problems.

Gorin is the most experienced of the test subjects--this is his third hypokinesia experiment. All told, he has spent 1½ years of his life in a state of hypokinesia, and in the words of Boris Morukov, the physician in charge of the experiment, his is already a world record today. And yet, he must lie around another half year. Or actually, several days less than that.

I trust Yevgeniy will not be offended if I call him a favorite with the public. There is some justification for this. After learning that Yevgeniy is a good hand at repairing radio receivers and televisions, and that he had restored to working order the appliances of his comrades, the medical technicians, and not only them, at first timidly, but then increasingly bolder, began to bring him their receivers from home. Yevgeniy was simply delighted--

it is something useful to do, and time goes faster. Naturally, the repair work is done while lying on his stomach. It must be said that he wields the soldering iron like a virtuoso in this position.

Of the remaining subjects, two have asked that their last names not be published, but have allowed me to say something for general information.

This is the third time that Vadim has taken part in such experiment. As can be seen, he has solid experience, and on the basis of this experience he considers that, for him personally, the worst is yet to come. He has learned to expend his effort gradually, economically, in order to last to the end. "I will lie here and think (he says quietly): soon there will be a holiday, November 7. I haul myself up to this day, like climbing a rope. Once there, New Year's Day is close by, and after that, spring, and then the last day of the experiment."

Vadim has left his "reserve funds" for the most difficult time: he likes to draw, even now he would enjoy drawing a bit, but he holds himself back. In return, when his force is at its end, the pencil will prove a godsend. For now, he is satisfied carving wood. His creation is a figure, at first glance forbidding, but I can detect a slight smile of irony. Probably because its creator is himself an ironic person.

Nikolay is a physical education instructor, with a master's degree in skiing. He has a son and daughter. He was a devoted mystery reader until a book about Moscow came into his hands. Suddenly, with surprise, he discovered a pleasure in imaginary strolls along well-known, favorite streets, fancying himself among the hurrying people. Such imaginary strolls distract him and, it seems, are helpful. Even so, he blurted out: "You know, I feel a great longing for the outdoors." This is his first time in the experiment. His decision to participate was by no means easy. He thought everything over, weighed the pros and cons. And here he is, among these resolute, serious individuals. Up to now, the hardest for him was the first month, when mental fatigue overwhelmed him like an avalanche, when his whole body protested against the forced immobility, when he was not yet acquainted with his comrades and had absolutely no idea how hard it is to live without getting up.

It would not be fair to talk about the subjects and say nothing about the man who is connected with them more closely than anyone else, a man to whom they unhesitatingly confide everything, even the most intimate. This is Boris Morukov, the physician in charge of the experiment.

Naturally, he would tell me nothing about himself. I had to make a "knight's jump" over him to his scientific director, doctor of medical sciences A. I. Grigoryev, a long and close acquaintance of his.

Grigoryev considers the most outstanding trait of Morukov to be his high, unusually high sense of responsibility. He is totally dedicated, sparing neither time nor effort in his work. So far as I know, his wife, who sees him after work at different times (but never early), has an understanding attitude.

What does this experiment mean to him? First, the prospect of doing something useful is attractive: to acquire experience on earth which might help those working in outer space. At present, the cosmonauts spend much time maintaining good physical fitness--around 2 hours per day, and science is seeking shortcuts to contract or minimize this time without sacrifice of effectiveness, and to make this time available for research, or even relaxation.

It must be just as hard for the subjects of this experiment as it is for the cosmonauts in flight. There is a tremendous psychological stress, as well as a tremendous stress on the entire body. There is also the danger that, in the condition of hypokinesia, the protective capacities of the body are weakened and become less resistant to various infections. Naturally, the strictest possible safeguards have been taken in this regard. In the wards where the experiment is taking place, cleanliness is maintained at the level of a surgery.

This is why such attention is being devoted to this experiment: the results are needed by those who are currently going up into space, and to those who will go on even longer space voyages tomorrow. It is also necessary in the clinics of earth, for those confined in bed by illness: often a physician encountering an unfamiliar symptom of disease in his patient will ask himself whether this is a sequel of the disease or an insidious manifestation of immobility--hypokinesia.

Well, now that we have decided that the experiment is critically important not only to the cosmonauts, but also to ourselves, falling into a state of hypokinesia probably without being aware of it, it is necessary to ask the question how then can the harmful effects of a sedentary lifestyle be counteracted.

In the first place, a system of physical exercises has been specially developed for this experiment, literally designed for all the muscle groups. Basically, it is similar to that done by the cosmonauts aboard space vehicles, only much more universal and complete, with a number of new components. The approach itself may be called an innovation. The cosmonauts in space run around five kilometers on the treadmill and pedal around ten kilometers on the exercise bicycle each day. The subjects in this experiment do the same, only with greater intensity. Furthermore, they perform a special set of exercises, preparing them for heavy physical loads. And there is constant uninterrupted, strict medical supervision.

Each of the three main phases of the experiment (every four months) involves a simulated earth landing, when the subjects spend some time in the centrifuge and the rough embrace of the g-forces. It is important for the doctors to know how the body will endure g-forces after lengthy immobility. Much importance is given to the so-called orthostatic test--determining the ability to maintain a vertical posture. It is important to evaluate their physical fitness. This is done on a treadmill, the inclination of which is gradually increased. The end result is that the subject, lying down as before

with bindings holding him against the treadmill track with a force equal to his weight, climbs uphill. The hill becomes increasingly more steep. I watched how this was done. It is a strenuous effort. But they continued to walk, overcoming the leaden fatigue and overcoming themselves.

Alexandr and Nikolay proved to have the greatest endurance. They sustained a fast uphill pace at maximum inclination of 28 degrees of the track for around 28 minutes. The speed was seven kilometers per hour. Believe me, very few of us, living in ordinary, customary conditions, could keep this pace.

An especially important moment has arrived for the investigators. Morukov calls the present period the "results examination", when everything that has gone before is as though cut off, and the abilities of the subjects (physical abilities, that is) as of the present moment are carefully examined.

Half a year has passed since the day when they crossed the threshold, leaving behind another life, which now appears to them wonderful, distant, as though it were not their own. A severe, at times exhausting, workload has begun, never stopping either day or night. The experiment continues even when the subjects are asleep, while a duty watch keeps awake behind the panels of monitors alongside them. Every day, every hour of these people is in the service of science.

I asked Anatoliy Ivanovich Grigoryev, first deputy director of the Biomedical Problems Institute of the USSR Ministry of Health and the scientific director of the experiment, how he would characterize the stage just completed. What was most important in this experiment?

The specialists in space medicine were confronted with a task--to prepare humans in space, during the flight, for return to earth. The new techniques have proved quite successful, but the duration of flights continued to increase, and new problems confronted life in space. To solve these, the medical workers had to take account of the age of the cosmonauts, whether they had flown before, as well as a series of other factors.

Summing up the previous phase, the following can be said. A number of fundamentally new data have been obtained with the help of new methods and investigations, including new loading tests to determine the body's reserves.

Already today it is possible to declare that the new regime of physical exercises has proven to be promising. It has been possible to forestall changes in the cardiovascular system and metabolic disturbances. The investigated pharmaceuticals have also proved to be effective in controlling changes in the calcium metabolism. This, also, must be acknowledged as a definite success.

Of course, we should not imagine that answers have been found to all the questions, or that all the problems have been solved. Such is not the case. Not all changes resulting from hypokinesia have been fully prevented. Certain

functional alterations occur. But they are all within the range of expectation. Such is the tentative and most general assessment of the outcome. The result of the first half of the journey.

Afterwards, I presented each subject with the same question: "Eventually the day will arrive when you will leave here. What will you do first of all?"

Yevgeniy Gorin: "If it is warm, I expect, I will take the entire family off to Manikhino, on the way to Riga, to eat shashlik."

Boris Apenin: "I will sit down with my daughter to do her lessons. And then we will have to travel somewhere outside the city. The whole family, of course. And then I will take my daughter to the seashore. She has not yet been there."

Aleksandr Yudin: "The first thing I will do is roll around in thick grass."

The others basically responded the same. Which I find to be perfectly understandable.

I walked through the park, where the evening shadows were beginning and the fallen leaves gave off a sharp scent, and I recalled the words of Apenin, uttered very quietly, as though to himself: "I will be lying here, looking, and with the corner of my eye I will see in the window that the leaves have already turned yellow. Autumn has arrived. Soon the snow will fall."

And next morning, looking out the window, I saw the snow lying on the green grass and the poplar leaves. I thought: "Now these trees will become dormant until the spring, and will then burst out in green, and these lads will still be lying there."

12717
CSO: 1866/13

MEDICAL RESEARCH PLANNED FOR USSR-FRANCE MANNED MISSION

Moscow SOVETSKAYA ROSSIYA in Russian 26 Nov 86 p 6

[Article by Anatoliy Ivanovich Grigoryev, Doctor of Medical Sciences, first deputy director of the USSR Public Health Ministry's Institute of Medical-Biological Problems]

[Abstract] The author comments on medical and biological studies which are being planned for the 1988 Soviet-French space mission, and on the training program of the two French candidates for this mission. He mentions that this program will include sessions under water in the pool at the cosmonaut center in preparation for a space walk outside the orbiting station "Mir."

The author notes that the mission's research program calls for further investigation of phenomena that were studied during the 1982 Soviet-French space mission. This applies in particular to the experiments "Tsitos-2," which is concerned with changes in the properties of microorganisms in zero gravity; "Bio-blok-3," which involves radiobiological studies of effects which heavy charged particles produce on biological specimens; and "Ekhografiya," in which studies are made of cosmonauts' blood circulation, intracardiac hemodynamics, and heart functions. During the mission, these studies will be continued with the aid of an improved "Ekhograf" instrument, and there will be new methods and equipment for the radiobiological research, according to the author. Also planned are psychophysiological studies of sleep and of changes in the sleep-awake cycle, and studies of calcium metabolism, which will include evaluations of mineral saturation of bone tissue, and studies of phosphorus-calcium metabolism and systems for its hormonal regulation.

FTD/SNAP
/8309
CSO: 1866/45

GAZENKO COMMENTS ON BIOLOGICAL LIFE SUPPORT SYSTEMS FOR SPACEFLIGHT

Moscow MEDITSINSKAYA GAZETA in Russian 17 Sep 86 p 3

[Article by Yu. Faybishenko correspondent (Kaluga)]

[Abstract] The article records comments of Oleg Georgiyevich Gazenko, director of the USSR Public Health Ministry's Institute of Medical-Biological Problems, regarding the Eighth All-Union Conference on Space Biology and Aerospace Medicine, which was held in Kaluga. He said that unlike the previous conferences in this series, which tried to give equal time to the whole complex of problems studied in this field, the latest conference had a central theme. It was ecology, its possible contributions and importance for space medicine, and also the role of space biology and medicine in gaining a better understanding of problems of ecology. The theme ran throughout papers read at plenary meetings of the conference and also in its sections, one of which was named "Problems of Ecology, Habitability and Hygiene."

Gazenko said that main directions of research in space ecology are aimed at developing biological life support systems for spaceships and orbiting complexes. Some specialists, he noted, think that such a system can be developed in 15-20 years. He said one aspect of the problems examined during the conference pertained to life support for manned interplanetary flights. One proposal for this was a system based on algae which would regenerate 100 percent of the oxygen necessary for a crew, so that only an emergency supply of oxygen would have to be taken along.

Gazenko noted that the conference's participants included cardiologists, pharmacologists, immunologists, gastroenterologists and other medical specialists. Among papers presented were ones dealing with space immunology and gastroenterology.

The article also contains brief comments by three foreign scientists who took part in the conference. One of them was D. Sharp, assistant head of an office of the U.S. NASA Ames Research Center, who commented on U.S. participation in studies done on Soviet biological satellites of the "Cosmos" series. He expressed appreciation for Soviet specialists' interest in an American proposal for experiments to be done on the next satellite, which is scheduled for launch in 1987.

FTD/SNAP
/8309
CSO: 1866/45

UDC: 612.014

RADIO RADIATION AND MICROWAVES: OPERATOR RADIATION SAFETY

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 25 Dec 85) pp 459-465

[Article by B.I. Davydov]

[Abstract] Norms and hygienic standards for radio and microwave electromagnetic emission have been established in many nations. This article discusses and compares the standards for the USSR, USA, Poland, Czechoslovakia, Canada, Great Britain and West Germany. Organizational aspects of radiation safety are also discussed, including safety-conscious placement of radar stations, electronic communications devices and other radiation sources with respect to the population and the locations from which the devices are controlled. Organization of working schedules and arrangement of working locations are also important organizational aspects of the problem. Workers, engineers and operators exposed to electromagnetic radiation should be given precise information concerning levels of radiation and potential harm, as well as instructions on safety techniques. The methodology used to estimate the balance between safety, cost and productivity in the application of ionizing radiation should be applied to nonionizing electromagnetic radiation as well.

Figure 1, references 23: 11 Russian, 12 Western.

6508/8309
CSO: 1866/141

LIFE SCIENCES

VARIATIONS OF GROWTH RESPONSES OF LETTUCE PLANTS (LACTUCA SATIVA L.) AS A FUNCTION OF SPACEFLIGHT EXPOSURE TIME OF SEEDS ON BOARD SALYUT-7 MANNED ORBITAL STATION

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR in Russian No 4, Jul-Aug 86 (manuscript received 3 Jan 86) pp 75-78

[Article by A.T. Miller and L.V. Nevzgodina, Institute of Biology of Latvian SSR Academy of Sciences, Institute of Medical and Biological Problems of USSR Ministry of Health]

[Abstract] The Latvian Academy of Sciences Institute of Biology and the USSR Ministry of Health Institute of Medical and Biological Problems designed and ran the "Bioblok-3" experiment on the Salyut-7 manned space station. This experiment exposed Lactuca Sativa seeds to spaceflight for 40 to 457 days. After the seeds were returned to Earth, they were sprouted and grown in a laboratory; the plant growth dynamics and the rate of growth of the primary root were determined against those of a control group. The plants were tested at several intervals up to the maximum lifetime of 93 days. Exposure to space station conditions suppressed primary root growth and reduced mineral element absorption. While the experiments did not allow the precise determination of which flight factors (acceleration, weightlessness or space radiation) caused the growth variations, it is hypothesized that the major factor was exposure to heavy charged particles. Although initial growth responses were retarded, no substantial changes were noted in the first generation harvest as compared to the control. The negative impact of space-flight exposure is manifest only in the early growth stages.

Tables 3, references 18: 14 Russian, 4 Western.

[130-8225]

/8309

UDC: 537.591

STUDY OF PHYSIOLOGICAL PROCESSES IN LETTUCE SEEDS AFTER DAMAGE BY HEAVY CHARGED PARTICLES

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR in Russian Vol 4, Jul-Aug 86 (manuscript received 3 Jan 86) pp 79-86

[Article by A.T. Miller, L.V. Nevzgodina, and Yu.A. Akatov, Institute of Biology of the Latvian SSR Academy of Sciences and Institute of Medical and Biological Problems of the USSR Ministry of Health]

[Abstract] The Latvian Academy of Sciences Institute of Biology and the USSR Ministry of Health Institute of Medical and Biological Problems conducted the "Bioblok-3" experiment in which three biostack assemblies (several plates with Lactuca Sativa seeds attached to special cellulose nitrate plates alternating with detector plates for recording tracks of heavy charged particles) were delivered to the Salyut-7 manned orbital space station in May 1982 and returned to Earth in stages. The last biostack was returned in April 1984. The biostacks enabled the determination of the location of a heavy charged particle impact on a seed within ±50 micrometers as well as the number of impacts. Three groups of seeds were exposed to spaceflight for 40, 201, and 457 days respectively, with a total of 1,124 seeds being exposed. The extent of the damage and possible recovery responses of the seeds after such exposures were determined. Photographs show a hole produced in a dry lettuce cotyledon following the passage of a heavy charged particle as well as the particle track in a moist cotyledon of a lettuce seed. Such particles cause little change in the subsequent growth processes of the plants after the seeds' exposure. There is no close correlation between the number of heavy charged particle impacts and the biological effect. After the longest flight of 457 days, in which the seeds experienced up to six impacts, the growth and accumulation of organic mass of the plants exhibited no reliable difference from the control group.

Tables 3, figures 4, references 22: 12 Russian, 10 Western.

[130-8225]

/8309

SPACE ENGINEERING

IMAGE ENHANCEMENT SYSTEM FOR SPACE PHOTOGRAPHY

Tallinn SOVETSKAYA ESTONIYA in Russian 6 Dec 86 p 3

[Excerpt] The nature of mysterious emissions from the head of Halley's Comet has been clarified with the aid of an unusual electronic retouching device which scientists of Kharkov developed. Use of this complex to process photographs of the recent visitor from outer space made it possible to see clearly the fine structure of streams of gases in the comet's tail, which form as a result of interaction between the solar wind and the matter of the comet's nucleus.

"Video information on astronomical objects can be obtained only at the limit of the technical capabilities of instruments," said Yu. Korniyenko, head of a laboratory of the Ukrainian Academy of Sciences' Institute of Radiophysics and Electronics. "Effects produced by our atmosphere, which distorts images even when observations are made at high elevations, are the main problem here. The question of how to 'retouch' images of space objects is highly important for specialists."

Research which was conducted in collaboration with astronomers of Kharkov University showed that this could be done with the aid of laser technology and a computer. Since they complement each other to a considerable extent, a unified complex was developed for processing space images. The computer evaluates pictures in accordance with the brightness of individual points and removes glares and haloes which interfere with visual perception, on the basis of laws of optical distribution. This maximizes the precision and contrast of images.

Pictures of Mars have been processed by this procedure, and it made it possible to analyze the relief of this planet in details that formerly were not possible. Work also has been done with photographs of Venus, Jupiter, and the moon. Further development of new methods of studying photographs will make it possible ultimately to solve the problem of taking pictures of objects in space through the atmosphere. Pictures taken from the ground will achieve as high a resolution as those taken from spacecraft.

FTD/SNAP
/8309
CSO: 1866/45

UDC: 629.783.062.2

MOTION OF SATELLITE WITH PERMANENT MAGNET RELATIVE TO CENTER OF MASS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 23 Jul 85) pp 527-543

[Article by V.A. Sarychev and M.Yu. Ovchinnikov]

[Abstract] A passive magnetic orientation system consists of a permanent magnet positioned along the satellite axis to be oriented and hysteresis rods positioned perpendicular to it. Motion of a satellite with such a magnet relative to its center of mass was studied with the following assumptions: the atmosphere is fixed in absolute space, the atmospheric effect on the satellite can be reduced to the drag operative at the pressure center and directed opposite the velocity vector of satellite center of mass relative to the air; the drag coefficient is not dependent on satellite orientation relative to the oncoming flow; atmospheric influence on the translational motion of the satellite can be neglected. A dynamically axissymmetric satellite is considered with the magnet placed along the axis of symmetry; the pressure center is on the axis of symmetry and its position is not dependent on satellite orientation relative to the oncoming air flow. Polar and circular orbits are examined, with a study of the influence of gravitational and aerodynamic moments, as well as the influence of orbital eccentricity on satellite motion in a magnetic orientation regime. It is shown that during satellite orbital motion the direction and value of the vector H of geomagnetic field strength at a given point in orbit change nonuniformly, resulting in the appearance of nondamping forced oscillations of the satellite relative to H. The parameters of elements of the orientation system can be selected in such a way that the amplitude of the forced oscillations will be small. These forced oscillations can be computed and they can be used as the working motions of the satellite. The magnetic restoring moment is decisive in the motion of a satellite with a magnetic orientation system (the remaining moments can be considered small). An analysis of the forced motions of a satellite essentially involves a study of its periodic motions.

Figures 12, references 18: 15 Russian, 3 Western.

5303/8309
CSO: 1866/4

SPACE ENGINEERING

UDC: 629.191

RAPID ROTATION OF SATELLITE WITH MAGNETIC DAMPER. 4. DISSIPATIVE EVOLUTION. RESONANCE EFFECTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86 (manuscript received 16 May 85) pp 553-563

[Article by Yu.A. Sadov]

[Abstract] In the first three parts of the study (KOSMICH. ISSLED., Vol 8, No 4, p 547, 1970; Vol 12, No 4, p 518, 1974; Vol 16, No 3, p 345, 1978) it was demonstrated that the motion of a satellite with a magnetic damper with a great ($O(\varepsilon^{-1})$) initial kinetic moment breaks down into a series of processes occurring at different rates (having different characteristic times of change). Processes with the characteristic times $O(\varepsilon)$, $O(1)$, $O(\varepsilon^{-1})$ were investigated. During such time intervals the mean kinetic moment of the satellite and its mean kinetic energy change little. After an initial sector of quite rapid decrease the mean potential energy experiences transition into a regime of slow change. Next the motion for the most part has a conservative nature in time intervals small in comparison with ε^{-2}. This fourth part of the study analyzes the further evolution of the system transpiring in times $O(\varepsilon^{-2})$. Expressions describing this motion are derived. These are written in the third approximation with averaging for fast rotation. Dissipation processes caused by slow oscillations of the damper magnetization axis relative to the satellite are the decisive factor in evolution during this time interval. A monotonic decrease in the mean kinetic energy of the satellite was discovered and the damping time for fast rotation was estimated. Secondary resonance effects are operative during this evolution process. These result in the appearance of peculiarities in the resonance ratios of the frequencies of unperturbed Eulerian motion of the satellite and stationary ratios of these frequencies close to resonance ratios.

Figures 3, references: 9 Russian.

5303/8309
CSO: 1866/4

UDC: 527.5:531.551

SIMPLIFIED METHODS FOR NAVIGATIONAL CONSTRUCTIONS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86
(manuscript received 5 Jul 84, after revision 22 Oct 85) pp 575-580

[Article by S.K. Gromov]

[Abstract] Simplified methods are outlined which can be used by control personnel, crews or engineers in the routine analysis and purposeful variation of any parameters of the coupling coordinates of a spacecraft and celestial sphere or planetary surface reference points. The advantage of these methods is that the results are presented in the form of nomograms, one of whose coordinates is the argument of latitude u, as a result of which their joint use is possible. Other specific data can be represented in the form of such nomograms should the need arise. As an example of usefulness of the methods, the case of determining the position of a shadow in orbit and its duration is analyzed. The range of applicability of the described methods can be extended to the atmospheric segments of spacecraft trajectories since these segments are brief and rigorously determined. The results of precise computations or actual measurements can be used in preparing special plots which make it possible to transfer the atmospheric segments of the trajectories onto the nomograms. Such nomograms can be used in integral evaluations of the capabilities of communication and tracking points and in making graphic the results of astromeasurements and in the mapping of planetary surfaces. Many other applications of such nomograms are conceivable. Such nomograms were used with great success during flight of the "Salyut-7-Soyuz" space complex.

Figures 3, references: 1 Russian.

5303/8309
CSO: 1866/4

UDC: 537.591.4.574.83

BACKGROUND COMPONENTS OF LOW-ENERGY CHARGED PARTICLES SPECTROMETER IN SPACE MEASUREMENTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 4, Jul-Aug 86
(manuscript received 5 Feb 85) pp 642-644

[Article by V.G. Kovalenko, R.A. Kovrazhkin, Yu.V. Lisakov and B.V. Polenov]

[Abstract] The background components of a charged particles spectrometer in which sorting by energies is accomplished using an electrostatic analyzer and in which the detector is an open secondary electron multiplier were analyzed. In such instruments the relationship of background components (assuming an identical response to fluxes of high-energy charged particles) differs substantially from instruments with scintillation detectors. The data used were measurements of the energy spectra of electrons and protons made with an RIEP-2802M spectrometer on the AUREOL-3 satellite using four detection units: two for protons and two for electrons. It was found that the spectrometer background considerably exceeded the mean value in the radiation belt regions, in the case of great intensities in the auroral zones, and with orientation of the inputs of the electrostatic analyzers on the sun. In the radiation belts the background was caused by high-energy charged particles, bremsstrahlung and secondary electron and ion emissions; in the auroral zones it was caused by charged particles not meeting the sorting conditions; in the case of direct orientation on the sun it was caused by the oblique incidence of UV radiation; with oblique incidence of UV radiation on the inputs of the electrostatic analyzers the main contribution to the background was from photoelectrons. The background caused by high-energy charged particles in the equatorial region was on the same order of magnitude as the background caused by low-energy particles in the auroral zones. Estimates of spectrometer selectivity can be used in making preparations for future space experiments.

References 6: 5 Russian, 1 Western.

5303/8309
CSO: 1866/4

ARCTIC ICE CONDITION MAPS RELAYED BY TV SATELLITE

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 6 Dec 86 p 1

[Article by G. Daygorodov (Moscow)]

[Excerpt] The USSR State Committee on Hydrometeorology and Monitoring of the Natural Environment (Goskomgidromet) and the USSR ministries of the merchant fleet and communications have begun joint testing of a television automatic information system (TAIS) on the Northern Sea Route in the western sector of the Arctic.

We asked Yu. Sinyurin, head of the Hydrometeorology Bureau of Goskomgidromet's Main Radiometeorology Center (GRMTS) and one of the initiators of the new experiment, to tell about it:

"Ice forecasts can now be displayed on ordinary television sets on board the nuclear-powered vessels 'Arktika,' 'Lenin,' 'Sibir' and 'Rossiya,' and on other Arctic icebreaker ships that are equipped with a special receiving antenna of the 'Ekran' color-TV system. The maps are transmitted from the Ostankino tower in Moscow.

"The process can be outlined as follows: data on ice conditions that are received from satellites at our GRMTS are fed into a computer. It converts this information into details of a map that are tinted in a 'pseudocolor.' These maps are then transmitted via the Ostankino tower and relayed by satellites to the television sets on ships. Periods of communication take place four times a week. Maps can be recorded on video tape if desired. Such information can be received by both Soviet and foreign vessels that are equipped with the necessary apparatus.

"The idea of television maps was proposed by A. Kapustin, head of a sector of the Murmansk affiliate of the Central Scientific Research Institute of the Merchant Fleet. The experiment is being conducted along the Northern Sea Route in the polar night, for the purpose of checking the system's performance during the darkest season of the year. The experiment will last until the end of December."

FTD/SNAP
/8309
CSO: 1866/45

SPACE APPLICATIONS

TEST SYSTEM FOR SATELLITE INSTRUMENTATION APPLIED TO ROBOT PRODUCTION

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 20 Nov 86 p 4

[Article by V. Lagovskiy]

[Abstract] The article reports that a system used for testing satellite instrumentation, which was developed by the USSR Academy of Sciences' Institute of Space Research (IKI), is being introduced for testing robots produced at the "Krasnyy proetariy" plant in Moscow. The system, which is called "Avtotest," is said to be applicable also to testing numerically controlled machine tools, or any equipment that is controlled by microcomputers. A. Stefanovich, senior project designer of IKI, is identified as the developer of the software for the "Avtotest." V. Lazarev, head of a design team from the institute, said that the team's assignment at the plant is to help create a section for automated testing of several dozen robots at once, which will free dozens of workers from monotonous, unproductive labor.

FTD/SNAP
/8309
CSO: 1866/45

SATELLITE SLR SYSTEM NOMINATED FOR STATE PRIZE

Kiev PRAVDA UKRAINY in Russian 14 Oct 86 p 3

[Article by V. Rvachev, member of the Ukrainian Academy of Sciences, laureate of the Ukrainian SSR State Prize, and Yu. Stoyan, corresponding member of the Ukrainian academy, laureate of the Ukrainian SSR State Prize]

[Abstract] The article discusses the significance and applications of the research involved in the work entitled "Development and Introduction of Radar Methods for Research (Remote Sensing) of the Earth's Natural Environment From Aerospace Vehicles." This work has been nominated for the Ukrainian SSR State Prize.

A number of solutions which the work's authors developed are said to have no counterparts in world practice. Radar methods which they developed can be used to detect tropical cyclones, determine their structure and ascertain their directions of movement; to determine the age (thickness) of ice and spot channels and openings in it; and to determine the structure of the ocean's surface (currents, frontal zones, areas where cyclones originate, etc.) The methods also are said to open up new possibilities for detecting and monitoring oil spills.

It is recalled that the work involved development of experimental prototypes of radar equipment which were tested on the Earth satellites "Cosmos-1500" in 1983, and "Cosmos-1602" in 1984. Side-looking radar carried by "Cosmos-1500" was developed at the Ukrainian Academy of Sciences' Institute of Radiophysics and Electronics. An industrial model of side-looking radar was tested on board the satellite "Cosmos-1766" this year.

FTD/SNAP
/8309
CSO: 1866/45

COMMENTS ON 'METEOR' SATELLITES, IONOSPHERIC RESEARCH

Frunze SOVETSKAYA KIRGIZIYA in Russian 17 Sep 86 p 4

[Article by M. Chernyshov]

[Excerpt] The "Meteor" system of meteorological satellites operated for almost 20 years, supplying us with information needed for forecasting the weather. This system was replaced in recent years with the improved system "Meteor-2." It includes two or three satellites in near-Earth orbits at an altitude of approximately 900 kilometers. In a single orbit each of these spacecraft gathers information from one-fifth of the globe.

The "Meteor-2" system is able to provide meteorologists twice a day with global information on the condition of the atmosphere and the distribution of cloud cover.

Meteorological satellites used to have an active life of one to two years; now it has been increased to three to four years. In addition to the satellites, the system takes in three ground centers for receiving and processing information. They are located in Moscow, Novosibirsk and Khabarovsk.

For the purpose of further improving the system, a third-generation meteorological satellite, "Meteor-3," was launched from our country in October 1985.

Scientists of socialist countries are doing joint work in the field of space meteorology, within the framework of the "Intercosmos" program. Soviet specialists are collaborating with scientists of other countries.

In the course of measurements made with the satellite "Intercosmos-19" several years ago, scientists observed an abnormal increase in the intensity of low-frequency radiation in the upper ionosphere several hours before the beginning of an earthquake. These observations were confirmed with the aid of the satellite "Oreol-3." Other earthquakes which took place during the flight of "Intercosmos-19" were examined. These earthquakes occurred in different parts of the globe: on the equator and at higher latitudes. Steady bursts of low-frequency radiation were recorded before and after an earthquake in every case.

The scientists can be credited also with another experiment--an active one--conducted with the satellite "Oreol-3." It involved a kind of artificial earthquake. Construction workers were building a section of a canal in the vicinity of Alma-Ata, and a powerful explosion was detonated there. The front of the acoustic wave reached an altitude of 100 kilometers five minutes after the blast. The satellite recorded two successive disturbances of the propagation of radio waves in the ionosphere.

FTD/SNAP
/8309
CSO: 1866/45

SPACE APPLICATIONS

SATELLITE COMMUNICATIONS TODAY

Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 86 pp 37-43

[Article by USSR Deputy Minister of Communications, Candidate of Technical Sciences Yu.B. Zubarev]

[Text] Satellites have opened up new prospects for the development of communications, television and radio broadcasting systems; the area of application of these systems has been expanded and new possibilities have appeared.

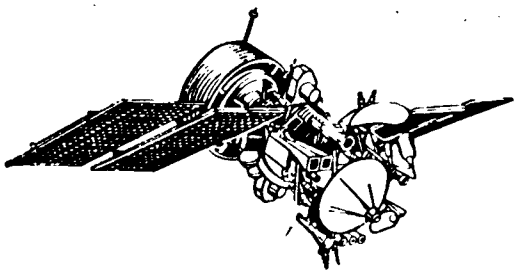
Earth-Space-Earth

The development of satellite communications systems was a vital necessity for the Soviet Union with its enormous territory (11 time zones!), where there are sufficient sparsely populated and nearly inaccessible areas. It would be practically impossible either from the technical or the economic viewpoint to arrange for the broadcasting of television programs over the entire territory of the USSR without satellites.

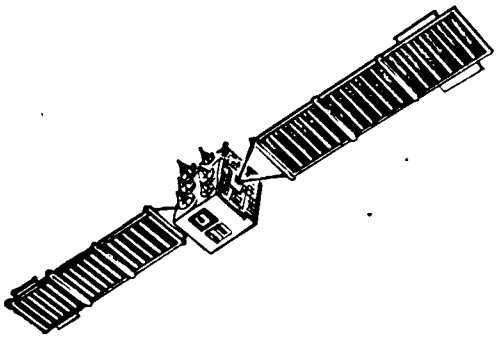
The launching in 1965 of the Molniya-1 ISZ [artificial earth satellite] marked the beginning of the development of domestic satellite communications and satellite broadcasting systems. This spacecraft made possible the exchange of television programs and telephone communications between population centers located near Moscow and Vladivostok. It was placed into an elliptical orbit with a period of revolution of 12 h; the next satellites--the Molniya-2 and Molniya-3 (1971)--had the same period of revolution. The relay stations of the Molniya-1 ISZ operated in the frequency band of 0.8 to 1 GHz, and the relay stations of the Molniya-2 and Molniya-3 ISZ's in the 6-GHz frequency band for transmission from the earth and the 4-GHz for transmission from the satellite. The launching of the Molniya-1 communications satellite (1965) served as the basis for the development in 1967 of the first satellite television broadcasting system in the world, the Orbita.

Twenty Orbita ground receiving stations had been constructed by the 50th Anniversary of the Great October Socialist Revolution; this made it possible for more than 20 million television viewers to view broadcasts from Moscow in cities of the Far East, Central Asia and our country's north. Today the ramified Orbita network numbers about 90 such stations.

The launching into geostationary orbit of the Raduga communications satellite with multichannel relay equipment for telephone communications and television broadcasting was accomplished in December 1975. This satellite made possible further development of the telephone network for communications with the Far East and our country's north. On 26 October 1976 the Ekran satellite was placed into geostationary orbit; this satellite was designed for relaying television programs to a principally new distribution network of ground stations--simple, inexpensive and not requiring constant attendance by highly skilled personnel. The Moskva [Moscow] distribution network for the reception of television programs, utilizing the new generation of Gorizont communications satellites, began to be developed as of 1980. The Moskva ground station network also consists of simple and inexpensive stations operating in the frequency band assigned to satellite communications systems. At the present time the Moskva, Orbita and Ekran satellite systems are making possible two-program television broadcasting in five time zones of the Soviet Union, and they include thousands of ground stations of various degrees of complexity. The network for telecommunications with remote regions of the country received further development with the entry of the Gorizont satellite.



Soviet Gorizont Communications Satellite

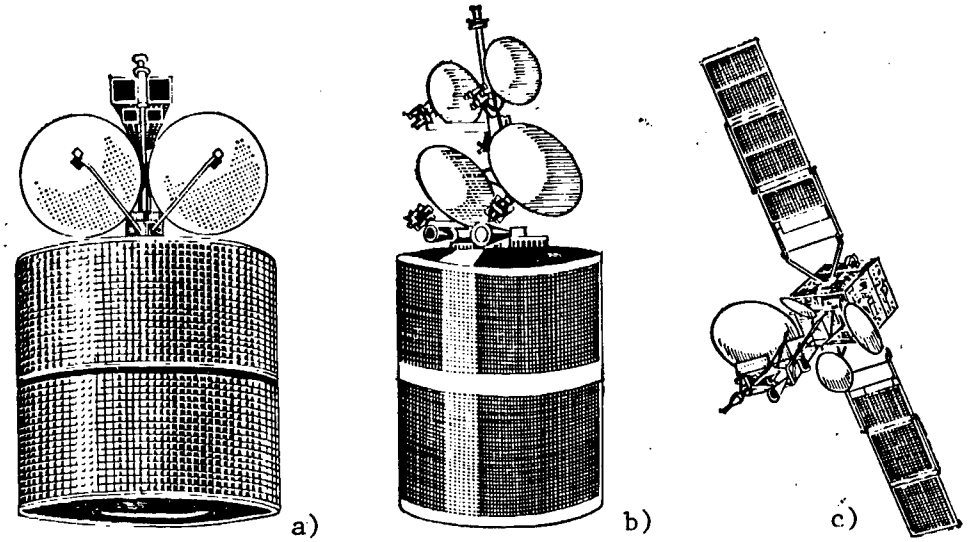


ECS--Artificial Earth Satellite Designed for West European Regional Commercial Satellite Communications System

Now the industry's specialists are confronted with the problem of steady, progressive development and improvement of the satellite communications system. It is necessary to use as extensively as possible artificial earth satellites for the purpose of multiprogram television and radio broadcasting, transmitting newspaper pages by the facsimile method, and for further development of telephone communications.

Besides in the USSR, national communications systems exist in the USA, Algeria, Brazil, India, Indonesia, Canada and other countries. Moreover, satellite communications systems are used also by such countries as Japan and France, which have small well developed territories with a high population density and a developed ground communications network. This is explained by the advantages of satellite communications.

The Intersputnik and Intelsat international satellite communications systems, which unite telephone communications lines and enable the exchange of television programs for more than 150 countries, have already been developed at the present time and are functioning.



Intelsat Artificial Earth Satellites Placed into Stationary Orbits for Global Commercial Communications System Belonging to Intelsat International Organization: From Left to Right, Intelsat-4, Intelsat-4A and Intelsat-5

Advantages and Shortcomings of Satellite Communications

But what are the principal features of satellite communications systems and their advantages and shortcomings? A unique advantage of these systems is the ability for all ground stations, not infrequently thousands of kilometers

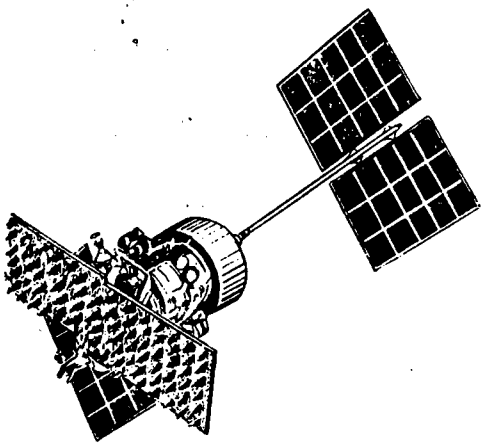
apart from one another, but simultaneously located in the range of an ISZ, to transmit and receive signals. This is especially important for countries with a large territory, for the transmission of immediate information, such as television and radio broadcasting programs, facsimile transmission of newspaper pages, etc. One ISZ makes it possible to connect a great number of ground stations by means of direct channels, without intermediate receiving and repeater stations, which considerably improves the quality of these channels and their reliability and simplifies the communications network. The number of channels is limited by the satellite's carrying capacity, but it (with today's level of development of equipment in mind) constitutes tens of thousands of telephone communications channels.

A certain number of ground stations can operate in the mode of multistation access in a single ISZ channel, which simplifies the organization of communications between them and reduces the amount of equipment for these ground stations, and also improves the utilization of the channel. The unassigned channel mode can be employed in a satellite communications system--when any station of the network operates at any frequency or in any time slot of a given ISZ channel, if they are not being used by other stations of the network and if permission has been granted through an agency order to occupy this frequency or time slot. This mode can be used for ground stations located in the territory served by a specific channel of the ISZ repeater station. Here, ISZ channels can be immediately switched for the purpose of serving a specific territory in accordance with changing demands for communications channels, which is especially important for a country like ours, which has a vast territory extending over many time zones, in which peak load times do not coincide.

An important advantage of a satellite communications system is the lack of dependence of the quality and cost of communications channels on the distance between ground stations. For this kind of communications system the cost of information transmission channels is determined by the cost of ground stations and their operating costs, as well as by the cost of operating ISZ repeater stations. No less important is the fact that by means of satellites it is possible to implement communications between points separated by natural obstacles, such as seas, oceans and mountains. Therefore, in spite of the relatively high cost of developing satellite communications systems, their use proves to be economically feasible beginning with a certain distance between ground stations. Progress in technology, especially space technology, constant improvement in methods of transmitting information, and improvement of the processing of source signals, making it possible to narrow the bands occupied by the signal, as well as to increase the performance in terms of error probability of the information transmitted, all this is considerably increasing the economic efficiency of satellite communications systems, and the possibilities of these directions have still been far from exhausted.

Among the shortcomings must be listed the long delay of signals going from a ground transmitting station to the satellite and from the satellite to the receiving station, as well as the change in frequency on account of the Doppler effect, especially for highly elliptical orbits. Two types of orbit are used in satellite communications systems: elliptical and geostationary.

Elliptical orbits, as already mentioned, were used for the Molniya satellites. The orbits are identical in all cases--with an apogess above the northern hemisphere of about 40,000 km. The satellite's period of rotation is 12 h, and the active portion of the period is 6 to 8 h. During this time the satellite moves along the ascending branch of the orbit from an altitude of 20,000 km to the apogee and then along the descending branch, symmetric with it. The lower portions of the orbit are not used, since the satellite's effective range is reduced and shifted. In order for the chosen region of the earth's surface to be serviced around the clock, there must be three satellites in an elliptical orbit placed 120 degrees apart from one another.



Ekran Soviet Artificial Earth Satellite. Designed for Relaying Color and Black-and-White Central Television Programs to Network of Community Receiving Facilities Located in Population Centers of Siberia and Far North

Ground station antennas are very massive and have a large "sail area"; therefore, a high input of energy and complicated equipment are required for tracking a satellite.

It is another matter when a satellite placed into a geostationary orbit is used. This orbit is located in the plane of the equator. The satellite's period of rotation is 24 h. Its direction of travel coincides with the direction of rotation of the earth. The orbit is circular. In this case the satellite becomes stationary relative to the station on the earth's surface. For this reason, the requirements for the equipment for tracking the satellite's motion and the very operation of the network of ground stations are considerably simplified.

Disturbing forces on the part of the sun and moon act on a satellite, as on any body located in open outer space. The action of these forces results in the fact that with time the satellite's mechanical trajectory changes, in connection with which the necessity arises of correcting its orbit. This is a complicated technical problem, especially for modern satellites whose period of active existence is 5 to 10 years.

For a satellite placed into geostationary orbit the Doppler shift does not exceed $\pm 10^{-8}$, whereas for a satellite placed in the orbit of satellites of the Molniya type this shift reaches as much as $\pm 1.5 \cdot 10^{-5}$.

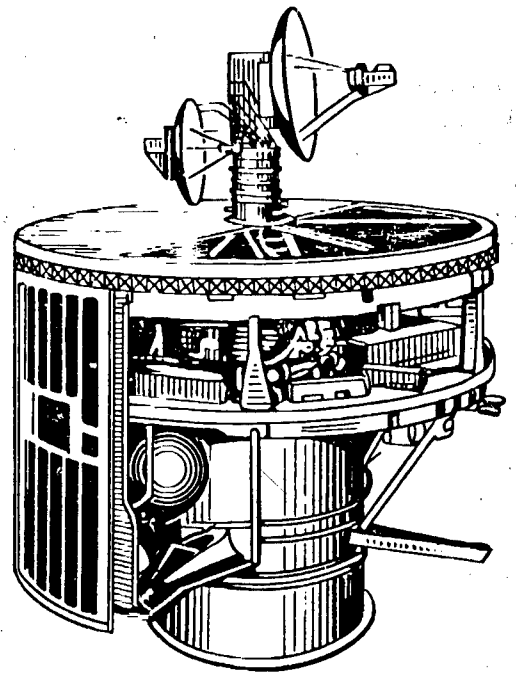
Among the shortcomings of this system must also be classed short-duration interruptions in communications due to two causes. First, interruptions of this kind are caused by the forced switching from satellite to satellite when using ISZ's placed in elliptical orbits; secondly, they are caused by the short-duration gating by the sun of ground station antennas. Interruptions in communications originate also because a satellite enters the earth's shadow region; however, all of these are not of long duration, are predictable, and exert an insignificant influence on the effectiveness of communications.

Development Prospects

Before talking about the development prospects for satellite communications systems, let us explain which factors determine the economic efficiency of such a system and what further ways there are to improve it. The system's makeup includes ground transmitting stations, satellites and ground receiving stations--for transmitting circular information; and ground transceiving stations and satellites for the telephone communications network. In addition, both networks require connecting lines making it possible to transmit information from the source to the user and connecting lines for the electric power supply. The ground stations themselves consist of an antenna with equipment for tracking the satellite; an antenna-waveguide transmission line through which energy is transferred from the station into the air and enters the receiving equipment from the air; receiving or transceiving equipment depending on the purpose of the station; and channel-forming equipment and equipment for linking with connecting lines. The communications satellite consists of antennas, transceiving equipment, power supply equipment and equipment for tracking the satellite's orientation, command guidance and measuring equipment, as well as orbit correction equipment. This list of the principal elements of ISZ's and ground stations does not exhaust all the components of a satellite communications system, for each element contains thousands of components.

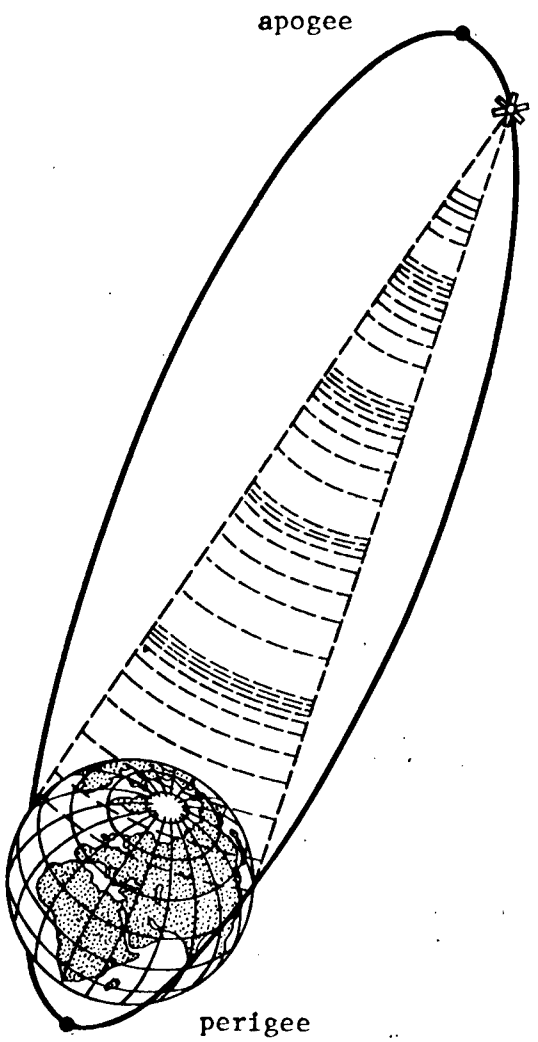
Improvement of the system relies on improvement of the characteristics of satellites and ground stations and of organization of the system's operation. The characteristics of satellites have been improved considerably over the 20-year period of development of satellite communications systems: The sensitivity of receivers has been increased, the equivalent isotropically radiated power has been increased, and the directivity of antennas has been increased; but it has been possible to achieve the most considerable successes in lengthening the period of the active existence of satellites, as well as in increasing their carrying capacity. Of course, the greater the carrying capacity, the less expensive a single communications channel is, and the longer the period of the active existence of a satellite, the less expensive it is to operate it on a yearly basis. The characteristics of a ground station are closely related to the corresponding characteristics of a satellite. For example, if the directivity of a satellite's antennas increases, then it is possible to reduce it by the same amount in ground stations, and after all

there are many of them, and the gain achieved in the satellite makes it possible to reduce the diameters of antennas, their weight, sail area and power consumption at all stations at once. For this reason, the basic direction for the improvement of satellite communications systems has become improvement of the technical characteristics of ISZ's, the simplification of ground stations and the improvement of their operating characteristics. As already mentioned, the ground stations of the Ekran system do not require permanent highly skilled personnel. It was possible to achieve this by using a satellite with improved characteristics. Work on improving the characteristics of ISZ's, such as the sensitivity of receivers and the directivity of on-board antennas, will be continued in the future, too.



Japanese Experimental ECS Communications Satellite

In order to utilize to the maximum the capabilities of satellite communications, it must be matched well with the country's Unified Automated Communications Network (YeASS). Satellite communications affords standard trunk and zone channels of the YeASS primary network, such as for television and audio broadcasting, facsimile transmission of newspaper pages, voice-frequency channels, and also analog and digital group channels. Besides, satellite communications affords channels directly for secondary YeASS networks; for example, distribution channels for television and audio broadcasting and newspaper facsimile transmission, which at the same time replace trunk, zone, and in some cases, also local sections of the network.



Orbit of Molniya-1 Satellite with Apogee over Northern Hemisphere of Earth

Since signals traveling through the satellite sections of YeASS networks experience a considerable delay on the order of 300 ms, for the telephone communications network it is necessary to take into account the undesirability of the formation of double and more hops passing through an ISZ and hampering contact between users.

Satellite channels must be used on direct and bypass routes in the YeASS secondary telephone network. Sometimes the inclusion in a channel of two satellite hops for a telephone network with hand-operated connections is economically justified. Experience in this kind of operation (this mode is

used in some national networks, as well as in the Intersputnik network) makes it possible to think that with a certain amount of practice "two-hop" lines are acceptable for users. It is possible to use direct satellite channels in the secondary telephone zone network for intercommunication between local stations, and to go out to the international network through a special tandem exchange. To talk about national networks abroad, the organization, close in terms of its principles, of special-purpose networks based on satellite lines for interchanging information between computers, for business communications, etc., has been extensively developed. The development of similar networks can prove to be more effective than solving these problems by utilizing YeASS primary channels.

And so, the following directions of research are necessary for the effective employment of satellite communications systems in the YeASS: development of the principles of and the implementation of communications and broadcasting systems enabling the optimal utilization of satellite channels--primarily for the problems which can be solved most effectively by means of satellite communications; improvement of the economic efficiency and reliability of satellite communications channels; and the maximum possible increase, at a given technical level, in the information transmitted, without increasing the frequency band and radiated power.

Satellite Communications Tomorrow

The most promising developments in the field of two-way communications systems call for a change from broad service zones to narrow ones: in order for the energy radiated by an ISZ to be directed only to that region of the earth's surface to which the specific information is addressed. Of course, narrowing of an antenna's beam is achieved either by increasing its dimensions or raising the frequency of the signals emitted. A number of frequency bands have been assigned to the satellite system. Two of them are widely used: 4 to 6 GHz and 11 to 14 GHz. The 4- to 6-GHz band is optimal for satellite communications systems, but it is overloaded, and besides it is used for ground communications lines. Therefore, the intense mastery of the 11- to 14-GHz frequency band has begun in recent times. In using it, it is necessary to take into account the additional attenuation of signals in atmospheric precipitation, which reduces the gain caused by the employment of narrow beams. In order to make possible in a communications system of the multibeam type an "everyone with everyone" mode, it is necessary to place on the satellite a number of complex pieces of equipment making it possible to transmit signals from one beam to another. For the purpose of solving this problem it is necessary to develop an ISZ which will be maintained in orbit with improved precision and will possess improved orientation of on-board antennas. Ground stations of the next generation will be used in such a system, and they will have simpler transmitters and receivers and a simplified antenna, and, consequently, will be less expensive and more reliable. A communications system utilizing narrow beams makes it possible to use one and the same frequency band on a satellite many times, and this will make it possible to solve a pressing problem--improving the "capacity" of a geostationary orbit.

As far as television broadcasting systems are concerned, because of ground feeder lines (radio relay and cable) and the Moskva, Orbita and Ekran satellite broadcasting systems, 93 percent of the population of the country can view Central Television's channel 1, about 80 percent two channels, and, as for three, only 28 percent of the population (data as of 1 January 1986). The possibilities of expanding the television broadcasting systems via the Ekran and Gorizont satellites have already been exhausted.

The need has been evidenced at the present time of providing the population of the country with two to three more television channels, and the development of a new satellite television broadcasting system utilizing the 12-GHz band (STV-12) is being planned in the USSR for the purpose of solving this problem.

The World Administration Radio Conference in 1977 (WARC-77) assigned all countries of the eastern hemisphere positions in geostationary orbit for satellites and frequency channels for television programs. For example, the USSR was offered five positions in geostationary orbit and 70 frequency channels. On this basis, the satellites of the STV-12 system, in accordance with local time, will have to enable the transmission of several Central Television programs to the entire territory of the USSR. In addition, an individual republic program must be transmitted to the territory of each Union republic.

Multichannel satellites located at the five positions assigned to the Soviet Union will come to be used in the STV-12 system. The reception of television programs from satellites will be accomplished with special units having an antenna with a 1.5-m-diameter reflector (community reception units with image quality not inferior to the quality of reception from ground television centers) and with a 2.5-m-diameter reflector (professional reception units having image quality corresponding to the quality of transmission through a YeASS trunk channel).

Countries of the socialist commonwealth which still do not have their own national satellite television broadcasting distribution systems will take part in development of the STV-12 system.

The implementation of these developments will make it possible to raise the technical level of satellite communications systems and to increase the number of services which can be offered to the people by the communications industry, as well as to improve the quality of individual services for the country's people, especially of its eastern regions.

8831
CSO: 1866/143

PLANS FOR INDUSTRIALIZATION OF SPACE DISCUSSED

Moscow ZEMLYA I VSELENNAYA in Russian No 2, Mar-Apr 86 pp 2-9

[Article by Academician V. S. Avduyevskiy and Doctor of Physical-Mathematical Sciences L. V. Leskov under the rubric "Space": "The Industrialization of Space Is the Next Logical Step"; source introduction, section titles and other boldface items given in all caps]

[Text] THE REPORT BY M. S. GORBACHEV, GENERAL SECRETARY OF THE CPSU CENTRAL COMMITTEE, ON 27 NOV 85, TO THE SESSION OF USSR SUPREME SOVIET MENTIONED A COMPREHENSIVE PROGRAM FOR PEACEFUL COLLABORATION IN SPACE AND THE PROSPECTS FOR THE INDUSTRIAL EXPLOITATION OF SPACE IN THE INTERESTS OF ALL HUMANITY. THIS PROGRAM IS A PEACEFUL ALTERNATIVE TO THE MISANTHROPIC PLANS FOR THE MILITARIZATION OF SPACE. IT INCLUDES THE CONDUCTING OF BASIC RESEARCH IN SPACE, THE CREATION OF GLOBAL SYSTEMS OF COMMUNICATIONS SATELLITES, THE STUDY OF THE CLIMATE AND THE ENVIRONMENT, THE DEVELOPMENT OF THE SCIENCE OF SPACE MATERIALS AND MEDICINE AND THE CREATION OF NEW SPACE TECHNOLOGY, INCLUDING ORBITAL SCIENTIFIC STATIONS AND MANNED CRAFT. WHAT CAN SUCH A PROGRAM GIVE TO HUMANITY IF IT IS REALIZED IN THE COURSE OF THE NEXT 25 YEARS OF THE SPACE ERA? THIS ARTICLE IS CONCERNED WITH THE ANSWER TO THIS QUESTION.

WHAT IS THE INDUSTRIALIZATION OF SPACE?

Twenty five years ago, for the first time, a human being left the earth--the planet's first cosmonaut, a citizen of the USSR, Yu. A. Gagarin, completed a space flight. His historic flight opened up the road into space in front of humanity: the quarter of a century that has passed since that significant day, 12 Apr 61, has been marked by new and important achievements in space research and exploitation.

However, in the first stage the activities of humans in space was directed mainly at scientific research. The earth's magnetic field and the properties of the ionosphere were studied. Spacecraft made it possible to learn a lot of new things about the Moon, Mars, Venus and the other planets. The Sun and stars were also investigated.

A little while later other work was also begun, the purpose of which was to derive immediate practical benefits from space resaerch. The first space communications satellites appeared and they made it possible to link the most remote corners of the globe with one another. Spacecraft started to be used for remote sensing of the earth.

Space data systems have gradually become widely used. Today satellites supply information on severe storms arising in the open ocean areas and on sudden changes in the weather on a very rapid basis and permit predictions about the future harvest several months before the harvesting begins. Using satellite data, geologists are conducting a serach for useful minerals and are looking for oil fields. Ocean vessel navigators confidently mark their routes on their maps, having determined the coordinates with great accuracy with the aid of signals coming from space.

The list goes on and on. But we will take note of one other item: space data systems have become a reality in our own time. At the present time it is impossible to imagine what the activities of many sectors of the economy would be like without the active use of the streams of rapid information being received from space.

SPACE DATA SYSTEMS ARE THE FIRST PRACTICAL TREND IN THE INDUSTRIALIZATION OF SPACE. Even today this is producing real income for many countries and the amounts of this income are calculated in the billions. In the future the practical significance of such operations will increase even more.

In recent years active research has also been expanded in another trend in the industrialization of space--the science of space materials and the manufacture of new and improved materials aboard spacecraft. According to the evaluations of specialists, in the next few years there will be an expansion of the industrial manufacture of various materials in space--from semiconductors used in microelectronics to unique medicines which will help medical personnel treat a whole slew of illnesses much better.

Space manufacturing in our time is experiencing a period of active growth. Both in the USSR and abroad a large quantity of technological experiments have been completed. They have been conducted on orbital stations and automated spacecraft.

THE SCIENCE OF SPACE MATERIALS AND SPACE MANUFACTURING ARE THE SECOND TREND IN THE INDUSTRIALIZATION OF SPACE. And the third? THE THIRD IS POWER ENGINEERING. This, of course, is a task that is much more complicated. Because of this, research on space power systems and their possible role in the industrialization of space has not yet proceeded beyond the stage of preliminary studies. Similar projets are very interesting and there is no doubt that there is a great future for many of them in the long term.

In addition to the three enumerated trends in the industrialization of space it is necessary to name one more, A FOURTH--SPACE MECHANICAL ENGINEERING. This is a special branch of mechanical engineering, oriented towards the development of long-term products of space technology, their assembly and ensuring

their functioning directly under orbital flight conditions. It is precisely the methods of space mechanical engineering that will serve as the basis for the construction of the data and industrial orbital complexes of the future.

And thus, over the 25 years that have passed since man's first flight into space, four basic trends in the industrialization of space have clearly taken shape. What can be expected from them in the course of the next quarter of a century?

GLOBAL DATA NETWORKS

The coming period of industrial exploitation of space will be characterized by the continuous improvement in space data networks, by the consistent expansion of the use in the most diverse sectors of industry and by the increase on this basis in the efficiency of manufacturing and in the intensification of the economy. The utmost expression of this process will be the emergence of a three-dimensional data and industrial infrastructure--a single earth data system--space. What will the stages of the creation of such an infrastructure look like?

Even in the next 5 years (1986-1990), further development of the space data systems is planned. Satellites will be used more and more actively in the interests of research on the earth's natural resources. A distinctive feature of the impending stage of this work is the more widespread use of multisensor measuring systems. Instruments which operate in the visible, ultraviolet, infrared and microwave bands of the spectrum will be used. The introduction of charge coupled semiconductor devices will ensure high resolving power for the craft. Digital data processing methods will also be incorporated.

Refitting spacecraft intended for remote sensing of the earth with more modern equipment for obtaining and processing data will lead to a sharp increase in the technical and economic efficiency of their use. On this same methodological basis the work on space monitoring of and optimal planning for the protection of the environment and the use of natural resources will receive new stimulation.

Substantial progress forward can be expected also in the field of meteorological observations from space. It is well known that the prerequisites for increasing the accuracy of weather forecasts are the further expansion of the meteorological network, increasing the operational efficiency of space data processing and the improvement of synoptic methods and equipment.

Space communications links will receive new stimulation. The yearly turnover of communications services, using satellites, just in the U.S. at present, amounts to 1.5 billion dollars. The prospects for such systems are generally acknowledged and the subsequent expansion of their network is not in doubt. In the future, first, there will be an increase in the number of communications satellites located in various orbits, including geostationary ones, and intended for serving both individual nations and regions, as well as for international communications. Second, it is expected that there will be a significant

improvement in transceiving cells. Third, there will be further development of ground transceiving stations and communications networks.

Systems for direct telebroadcasts from satellites to domestic television sets will be futher developed. Such reception is possible using antennas and amplifiers, the cost of which will not exceed the price of an ordinary black-and-white television set. Direct television broadcast systems have particularly good prospects for nations and regions with low population densities.

The rapid growth of regional and international data streams, transmitted via satellite, will result in new types of communications satellites being developed by the end of the century. The prospective communications satellites will be designed with a large number of channels--10,000 and more. The intersatellite communications links will be developed further, with a special place being alloted to links operating in the EHF band, which are less sensitive to interference and require less cumbersome antennas.

There is a possibility of providing duplex radiotelephone communications, using ultraminature individual radio stations, for example, in the form of wristwatches. There will be an increase in the quality of the data through the use of multibeam directional antennas on the satellites.

New forms of data services will attain widespread distribution: the conducting of video teleconferences and the rapid transmission of scientific, technical, administrative and other data.; there will be new forms of organization for education and cultural life. It will be possible, without leaving one's home or a library, to obtain quickly practically any data of a reference nature, using international data banks. Of course, the establishment of the new service industry requires the gradual organizational restructuring of the economy, of the health care sector and the scientific research and educational sectors, which should learn to actively use the new industrial factor--the planet's data field. Provision of the corresponding ground equipment is also required.

SPACE MANUFACTURING

Conditions on board a spacecraft flying around the earth differ sharply from those which exist on the earth's surface. They include the vacuum of space, the temperature jumps on the hull of the craft and the high-energy components of solar radiation which are usually absorbed by the atmosphere.

However, engineers long ago learned to create all these space conditions on the ground when it was necessary. All except one--the prolonged state of weightlessness. On the ground such a state can be produced only for a few seconds in all--in special chambers, inside of which, from great heights, a container filled with instruments is dropped, or on board a plane making a flight over a specially selected trajectory.

Space flight is another matter: a satellite circling the earth is in a state of dynamic weightlessness, wherein the force of weight is compensated for by the forces of inertia. On board the satellite the state of weightlessness is prolonged for a very long time: months and years--so long as the space flight continues.

It is true that there is not complete weightlessness on board the spacecraft: it experiences small accelerations caused by the resistance of the atmosphere; the temperature control fans and other equipment cause constant vibrations and the orientation and course correction systems' engine units create impulsive accelerations.

For the first time, measurements of these small accelerations were made using special accelerometers on board the Soviet Salyut-6 orbital station. It turned out that the constant was not great--no more than 10^{-2} cm/s^2. The amplitude of the vibrations can be greater: if, for example, the crew carries out exercises on a treadmill, it amounts to 1 cm/s^2. In the unmanned flight mode the disturbances are minimal.

But what can weightlessness yield? The absence of weight leads to the fact that many well-known physical processes proceed in a different manner. The law of Archimedes ceases to be effective and, consequently, it is possible to obtain in a stable form liquid mixtures which on the ground would immediately separate according to density. And if these are melts of metals, glasses or semiconductors, then it is possible to chill them down to the hardening temperature right in space and then return them to the ground. The properties of such substances will be greatly unusual.

There will also not be the usual gravitational convection in space. Specialists in the manufacture of semiconductors know well that many of the defects in these materials are caused precisely by convection. And biochemists are also familiar with the less pleasant side of convection: in order to obtain many biologically active substances in a particularly pure form electrophoresis methods are used. Convection also interferes with the solution of this task...

Therefore, when long-term orbital stations and automated spacecraft appeared, scientists, engineers and technologists began to prepare experiments aimed at examining the advantages of weightlessness for the manufacture of materials. A large number of such tests were conducted. In the Soviet Union they were conducted aboard all the orbital stations, beginning with the Salyut-5 station. Automated spacecraft were used for this purpose, as well as high-altitude rockets. For 10 years, since 1976, in the Soviet Union more than 600 technological experiments have been conducted on board manned and automated spacecraft. A significant number of experiments have also been conducted abroad.

The experiments confirmed that the scientists were correct in that many properties of materials obtained in weightlessness were significantly better than those of control models on the ground. But something else also became clear: in order to select correctly substances that were most suitable for manufacture in space, to create the optimum arrangements and to select the technological processes, special scientific research is needed. It is necessary to develop a new scientific discipline--the physics of weightlessness, to serve as the theoretical base for the science of space materials and manufacturing.

And such a science has already been created in basic terms. Methods for the mathematical simulation of the processes of the hydromechanics of weightlessness have been developed with the aid of a computer. On board the orbital

stations physics experiments will be carried out--on the Salyut-7 station, for example, the Pion-M [Peony-M] equipment is being used for this purpose.

At the same time tests have begun on the next generation of units intended for experimental and industrial manufacturing of materials in space. One of them--Korund [Corundum]--has already undergone successful tests aboard the Salyut-7 station; it is intended for the in-space growing of semiconductor monocrystals with unique properties.

Experiments conducted on board the Salyut-6 and -7 orbital stations in the field of the science of semiconductor materials made it possible to isolate classes of semiconductor monocrystals, the manufacture of which is profitable to begin in space. Such materials will be used for the manufacture of future infrared radiation receivers (cadmium-mercury-tellurium, lead-tin-tellurium), semiconductor lasers (sulfide and cadmium selenide) and microwave instruments (gallium arsenide and indium phosphide).

The transition to experimental and industrial manufacturing in space of unique materials in the next few years is also being planned in the U.S. and Western Europe. During flights of the multiple-use transport ship, the Space Shuttle, experiments are being conducted regularly on the development of equipment and technology for the manufacture of an ultrapure hormone using the electrophoresis method. We would note that the research conducted reminds one of a detective story: the American firms, McDonnell Douglas and Ortho Pharmaceutical, having tackled such a task and fearing competition, have kept this hormone preparation a secret. For reasons of secrecy the firms did not entrust the work to the other astronauts--the experiment on board the spacecraft was conducted by an associate of the firms. On the other hand, however, the American firms' representatives openly declared that, from the sale of this hormonal preparation, which is a new and effective medicinal agent, they calculate that they will receive a yearly income of several billion dollars by the years 1988-1990...

In order to establish in space the full-scale manufacture of semiconductor monocrystals, biologically active preparations and other materials, it is not enough to put into operation a new generation of technological units. It is also necessary to have special spacecraft. Research has indicated that it is necessary to reduce to a minimum the level of the accelerations on board such craft. Power supply units with an initial capacity of tens of kilowatts, and later even of hundreds of kilowatts, are needed.

In order to manufacture the materials it would be most convenient to use automated satellite platforms with production equipment and which would carry out autonomous flight. From time to time, using their own engine units, these satellites would come together with a base orbital station. Cosmonauts on the station would replace specimens and make repairs to the equipment as needed.

And, as before, research would continue more conveniently on the station. Here there are many new prospective tasks. This is one of them. On the ground it has not been possible to grow sufficiently large crystals of albumen--convection hinders this. In weightlessness it is possible to grow such crystals and,

if an x-ray machine has been supplied to the station, to study their structure. The data obtained in these experiments will then permit ground laboratories to efficiently conduct work on the purposeful restructuring of albumen using genetic engineering methods. Thus, in space it will be possible not only to manufacture new materials, but also to obtain valuable scientific data which will yield the possibility of organizing new and highly efficient technological processes on the ground.

Preparations for experimental-industrial and industrial manufacturing of materials in space are being actively carried on in the USSR, the U.S., Western Europe and Japan. According to the estimates of American specialists, just in the U.S. the sale of materials manufactured in space will yield an income by the year 2000 of nearly 60 billion dollars.

SPACE POWER ENGINEERING

There has been publication and widespread discussion in print of the plans for space-based solar power stations intended to supply energy to the ground. It has been proposed that such stations, weighing nearly 50,000 tons, be placed in geosynchronous orbit 36,000 km above the earth's surface. Enormous solar batteries and converters will transform the sun's radiant energy into microwave radiation, a well-focused beam of which will be aimed at the ground, where it will be converted into a commercially usable electrical current. The capacity of a space solar power station would be nearly 10 GW.

American specialists put forth proposals to create a network of such power stations by the end of the century. A more thorough analysis, however, indicated that at the same time a number of important factors had not been taken into consideration (Zemlya i Vselennaya, 1981, No 6, p 2--Ed.). The cost of such power stations turned out to be much higher than the authors of the plans suggested. It would be necessary to commission a whole fleet of new launch vehicles with colossal load capacities. During the flights of these rockets an intolerably large quantity of carbon and nitrogen oxides and other harmful substances would enter the atmosphere. There were also other doubts about the advisability of immediate implementation of the space solar power station plans.

At present a more cautious point of view on the problem of the space solar power stations has prevailed: planning research is continuing, but the matter of implementation of the plans has been postponed until the 21st century. However, this same research has turned out to be very useful: principles for building highly efficient power converters were discovered and optimum methods for the transmission of the microwave radiation beams to the ground have been studied...

While the creation of full-scale space solar power stations has been postponed till the 21st century, another matter will be a reality by the end of the 20th century--the development of space solar power plants with capacities of from 100 to 300 kW. Such power plants are necessary for the operation of the spacecraft making up the global data networks and for the industrial orbital complexes.

There is every reason to expect that in the years form 1986 through 1990 new and substantive successes will be achieved in the development of highly efficient and economical photovoltaic converters for generating electricity from solar energy. It is necessary to ensure a reduction in the cost and specific weight of the photovoltaic converters and an increase in their efficiency and operational life.

The following trends have the best prospects for solving the problems of the photovoltaic converters: a transition to thin-film technology, primarily involving the use of amorphous silicon, and the development of cascade photovoltaic converters made of silicon, gallium arsenide and other semiconductor materials.

Photovoltaic converters made of amorphous silicon are more technologically effective and suitable for the manufacture of large-size solar batteries and in the long run they will ensure a maximum reduction in cost. In Japan and the U.S. at the present time the technology has been realized for the continuous manufacture of photovoltaic converters made of amorphous silicon on a thin-film substrate, with an efficiency rating of 10 to 12 percent. And for cascade structures of the silicon-germanium type there are indications that it may be possible to increase the efficiency to 18 to 24 percent.

According to the estimates of foreign specialists, successes in the technology for manufacturing photovoltaic converters made of amorphous silicon will yield a genuine reduction in their cost by as early as 1990 of up to 50 cents per watt. With this goal in mind it is necessary to develop means for sharply increasing the speed for depositing the silicon on the substrate, for improving the properties of the deposited layers and for working out methods for obtaining the cascade structures.

The use of cascade photovoltaic converters in conjunction with solar radiation film concentrators for the creation of high-capacity space power plants is also of significant interest. In order to increase the efficiency of the power plants it is possible to use as well a turbine type machine converter together with a photovoltaic converter in the plant.

Solar radiation film reflectors in the 21st century may also find independent practical application in the solution of the problems of the industrialization of space, for example, for nocturnal illumination of individual regions of the earth and, in the more distant future, for focusing intensified beams of solar radiation on ground-based solar batteries. The production on the ground of additional ecologically pure electrical power through the use of solar radiation will make it possible to proportionally reduce the expenditure of mineral fuels, especially oil. In addition, the increase in exposure to sunlight in individual regions will make it possible to intensifiy the activities of the agro-industrial complexes.

As far as space power plants with a capacity of up to 1 GW and more go, they may find application in the transmission of finely focused beams of energy, for example, in the form of laser radiation and for intraorbital transport tugs equipped with electric rocket engines. With the significant growth in the

shipment flow between various orbits in near-earth space such a solution will also be economically advantageous. However, this requires the preliminary solution of a complex scientific and technical problem: the creation of a sufficiently efficient laser power plant which will provide for the conversion of solar radiation energy into laser radiation. It is doubtful that it will be possible to solve such a problem earlier than the beginning of the 21st century.

SPACE MECHANICAL ENGINEERING

Fulfillment of the entire discussed circle of complex and multi-plan tasks in the industrial exploitation of near-earth space is possible only on the basis of a qualitatively new approach to the creation of the space equipment itself. It is necessary to build the data and power-producing orbital complexes of the future on new principles.

These complexes will be complicated, multi-functional structures. In several instances, along with the base orbital station, they will be made up of autonomous modules and platforms performing a group flight over mutually coordinated orbits.

In order to ensure a sufficiently high degree of economical efficiency, the orbital complexes should be lightweight and inexpensive. Designed for operations in weightlessness, the modules and assemblies of the orbital complexes can be placed on delicate girders. However, when placed into orbit, these structures should support significant loads. In order to put them into space, transport ships with limited-size cargo compartments will be used. In order to reconcile such contradictory requirements, the space structures should be prefabricated to the maximum extent possible.

Taking into consideration the systematically diverse nature of the specific problems in the industrialization of space, the orbital data and industrial complexes should also satisfy a number of other requirements: versatility, maximum adaptability and a capacity for successive restructurings directly in orbit. Obviously, these complexes need to be constructed on the module principle. The design of orbital industrial complexes will include systems for automatic damping of the vibrations and impact loads which occur during the docking of transport ships.

The methods for in-space construction of orbital complexes should be automated to a high degree. During the assembly of space structures remote-controlled telerobots will be used.

There is every reason to consider this range of complex operations, many of which will require essentially new technical solutions, as a new branch of industry--space mechanical engineering. Even in the next few years space mechanical engineering will become the very technical foundation on which there will develop a broad front of work on the industrialization of space.

However, the practical significance of space mechanical engineering is not limited by its role in the industrial exploitation of space. The new technical solutions, prospective technological processes and new construction materials

will undoubtedly turn out to be useful in other sectors of the economy as well: as a result of the incorporation of the innovative achievements, they will obtain a new and powerful stimulus for development.

Ther is no doubt that the industrialization of space is a worthwhile alternative to the plans for its militarization and conversion into a menacing source of danger to the very existence of life on our planet. Work on the industrial exploitation of near-earth space would make it possible to unite the forces of all humanity for the purpose of solving the problems confronting it.

The creation of global data networks and the emergence of a unified planetary data field will greatly increase efficiency in the use of the scientific and technical potential which has been accumulated by humanity, will advance the existing communications channels to a qualitatively new level, will enable the rapid transmission to a consumer of practically unlimited streams of data and will create a new service industry. Space manufacturing will yield new and unique materials for the economy and will open up new prospects for the health-care sector. Space power engineering and mechanical engineering will give new impetus to the development of many sectors of the economy and will assist them in making a rapid transition to the rails of intensification.

But all these prospects can be turned into reality when one main condition is maintained--the preservation of peace on the earth. And for the Soviet peoples and for all of progressive humanity there is no task more important and precious that the defense of peace on our planet to ensure a bright future for our planet.

12752
CSO: 1866/91

COSMONAUTICS IN RELATION TO SOVIET ECONOMIC DEVELOPMENT

Moscow KOMMUNIST VOORUZHENNYKH SIL in Russian No 8, Apr 86 pp 54-56

[Article by A. Demin, "Cosmonautics and the National Economy"]

[Text] The 25th anniversary of the world's first flight of a spaceship around the earth with a man on board was marked on 12 April 1986. This flight was made by the communist flier-cosmonaut Yuriy Alekseyevich Gagarin.

During the quarter-century which has elapsed Soviet cosmonautics has successfully solved a series of such highly complex problems as the flight of unmanned vehicles to the moon and back, landing of automatic laboratories on Mars and Venus, automatic docking of flight vehicles in orbit, emergence into open space and the execution of unique experiments in interplanetary space. An outstanding achievement of Soviet science and engineering was the "Vega" project, making it possible to supplement our knowledge concerning the origin and evolution of the solar system.

The orbital scientific station "Mir" was launched in the Soviet Union on 20 February, on the eve of opening of the 27th CPSU Congress. It was outfitted with a new docking system with six docking units and constitutes the basis for constructing a multipurpose permanently operational manned complex with specialized modules for scientific and economic purposes. On 15 March the station received its first space proprietors, USSR cosmonauts L. Kizim and V. Solovyev, "arriving" on the station in the "Soyuz T-15" ship. Today we are witnesses of outstanding achievements in many branches of knowledge which begin with the word "space": space physics, space chemistry, space metallurgy, space biology, space geology, space communications, etc. Cosmonautics has been transformed into an indispensable part of science, a tool of the national economy.

An exhibit at the recently reconstructed "Space" pavilion at the All-Union Exhibition of Achievements in the USSR National Economy convincingly tells of the achievements and prospects of Soviet cosmonautics. The exhibit is always crowded. The interest of Soviet people in everything associated with the work of our cosmonauts and researchers in distant orbits is enormous. Indeed, space is the outpost of Soviet science. The acceleration of scientific and technical progress, the most important condition for intensification of the economy, to a great extent is dependent on the results of space research carried

out in the interests of development of science and technology. This means solutions are needed for those problems which have been posed before the country by the 27th CPSU Congress.

Familiarization with the exhibits begins in the entrance hall, where there are portraits of the founders of Soviet rocket technology and cosmonautics: K. E. Tsiolkovskiy, S. P. Korolev, N. I. Tikhomirov, M. K. Yangel, M. V. Keldysh and others. With their intellect and talent they blazed the trail into space for the first rockets, satellites, ships and entire complexes. K. E. Tsiolkovskiy once said: "Is this not splendid? A great future is ahead for mankind and it is linked to the conquest of space."

Yes! Splendid, indeed! The legitimate feeling of pride in Soviet science, opening up the era of space flights, fills the hearts of the Soviet people. We have much to be proud of. It is sufficient to familiarize oneself with the exhibits in the main hall of the pavilion, where there is display of dozens of copies of space technology -- artificial earth satellites, spaceships and complexes, instruments and apparatus which are used in carrying out the most different kinds of research, in order to comprehend the tremendous scales of space conquest.

Visitors learn that the investigations of the earth which are carried out can be classified into two subsystems: photographic and operational. The photographic subsystem is intended for study of slowly transpiring processes and stable formations on the earth's surface. This is done using specially developed cameras having high resolution and geometrical accuracy. The operational subsystem is used in studying rapidly changing components of the environment. This is accomplished using optomechanical scanning apparatus with high and intermediate resolution with a scanning band of 180-200 and 500-700 km.

A space method for regional geological study of broad areas has been introduced for compiling specialized space photogeological maps. These show major geological structures, a significant percentage of which were earlier unknown. These maps serve geologists as a basis for studying the patterns of distribution of mineral deposits and detecting promising petroleum and gas and ore regions. They are helping in selecting priority areas for detailed geological reconnaissance and exploration work. Thus, dozens of new deposits have already been discovered.

Visitors are being familiarized with the "Salyut-6" station, on display at the exhibit. The name of this ship is linked to the names of many cosmonauts and is associated with many scientific discoveries. Flier-cosmonauts V. Lyakhov and V. Ryumin, aboard this station, in their time assisted in improving the efficiency of the reconnaissance work of fishing fleets. The instrumentation and apparatus aboard this station was used in implementing a whole series of programs drawn up by specialists in different branches of the national economy and by scientists.

Soviet cosmonauts have carried out 150 technological experiments and under weightlessness conditions have obtained more than 200 samples of different materials. The objective of this work was clarification of the laws of

formation of materials under microgravitation conditions and a quantitative evaluation of the influence of gravitation on elementary physical and chemical processes and technological regimes. The unique conditions in space, such as weightlessness, a deep vacuum and superlow temperatures, have been used by researchers for obtaining materials with unusual physicomechanical properties, large monocrystals, ultrapure substances, including pharmaceuticals.

Aboard the "Soyuz-6" ship cosmonauts for the first time in history carried out a space technological experiment which demonstrated that under weightlessness conditions the method for the melting of metals with an electronic beam can ensure a high quality of welding.

Now experiments with remote sensing of the earth, biological, technological and medical research, as well as observations under an astrophysical program, have already become traditional. A major role in the implementation of research programs is played by the modern technological and experimental equipment which is delivered to the station by the unmanned "Progress" freighters. These ships replenish the supplies of expendable materials and fuel and facilitate broadening of the scientific research program.

The cosmonauts, who often are present in "their" pavilion, share with visitors their impressions of the orbital flights and their participation in scientific experiments. Work in space enables them to draw deep generalizations. For example, the flier-cosmonauts concluded that investigation of the earth from space should assist in solving two planetary problems: preservation of the environment and study and efficient use of the natural resources of our planet.

Geophysical research from orbit brings together the interests of different branches of the national economy. For example, the search for promising petroleum- and gas-producing regions by means of a space survey is more and more entering into the work practice of geologists. Commercial satellite systems have been organized for ensuring two-directional intercontinental communication with the use of artificial earth satellites.

Communication and television systems are being reliably developed in our country. The "Orbita" communication system, which includes "Molniya" satellites in high elliptical orbits, as well as "Raduga" and "Gorizont" satellites in geostationary orbits and surface receiving and transmitting stations, is being improved and expanded. The number of stations, which together with the reception of television and radio programs, are used in telegraphic-telephonic communication and the reception of images of mats of central newspapers, has increased.

Photographs of the earth's cloud cover are taken and observations are made in the IR spectral range using a system of operational meteorological satellites. The data received from the meteorological satellites are regularly used for refining 1- and 2-day weather forecasts. The "Meteor" space system already successfully used in the USSR for more than 17 years ensures an annual saving to the national economy of one billion rubles.

The expenditures on a space survey of the earth's surface, scaled to a unit area, are smaller by a factor of 10-15 than for an aerial photographic survey. This was confirmed, in particular, by experience in planning, construction and development of projects in Eastern Siberia (zone of the Baykal-Amur Railroad), Kazakhstan and Central Asia.

Executing a state mandate, the crew of the orbital space complex "Salyut-7"-"Soyuz T-13," Vladimir Dzhanibekov and Viktor Savinykh, taking into account the requirements of land improvement specialists, photographed the irrigated lands of Uzbekistan, Turkmenistan and Kherson Oblast. Photographs of the Southern Urals and the regions of Southern and Southeastern Kazakhstan taken from space were needed for carrying out measures for the preservation of the environment, as well as city planning. The work program of the cosmonauts included study of the southern regions of the European part of our country, the Caspian Lowland, interfluve of the Amudarya and Syrdarya, annular structures in the Central Kyzylkum, Pamir and Tien Shan mountain ranges, as well as the Baykal and Far East regions.

Then the cosmonauts participated in still another aerospace experiment called "Gyunesh-85." Research under the name "Gyunesh" was carried out for the first time during the third main expedition in 1984. The practical results of this experiment were highly rated by specialists. The Gold Medal of the Exhibition of Achievements in the USSR National Economy was awarded for a map of fault lines in the Greater Caucasus Range, from which it is possible to determine the structure of rocks at a depth as great as 80 km.

Bioengineering specialists today have an unwavering interest in experiments for obtaining, under spaceflight conditions, particularly pure, biologically active substances. In this connection, good results are given by the new "EFU-Robot" automatic electrophoretic apparatus. It has more inspiring dimensions in comparison with its predecessor, the "Tavriya." Now the cosmonaut only inserts an ampule with the initial material into the chamber and sets the required program and the apparatus itself signals the end of the process. The operation of evacuation of the precious purified substance is also automated.

One of the problems is related to the creation of singular "workshops" in circumterrestrial space for obtaining ultrapure substances, materals and valuable biological and medical preparations. Even today it is evident that under weightlessness conditions such substances and preparations are produced in purer form and the processes themselves transpire more efficiently than on the earth. Unfortunately, they can be obtained only in small quantities. However, the need of the national economy and science for them is great.

It is well known that the results obtained in the field of satellite geodesy are especially important for mapping and systematization of natural resources, increasing measurement accuracy and also for studying our planet. Today efforts have been concentrated for the most part on development of instrumentation for use in laboratory experiments, on aircraft and artificial satellites for the purpose of developing systems and methods for the collection of information on conditions in circumterrestrial space and on natural resources, being of interest primarily for meteorology, oceanography, hydrology and geology. A comparison of space data with the results of other environmental research

confirms the important role of observations from space. For example, in the process of interpretation of photographs of the Rudnyy Altay taken from the "Salyut" orbital station it was possible to introduce important changes in earlier compiled geological maps of this region so important in the national economy.

In the practical use of remote sensing materials the Soviet Union is involved in broad international cooperation both on a multilateral basis (within the framework of the "Intercosmos" program) and on a bilateral basis. Agreements have been concluded with all socialist cooperation countries.

In 1985 Soviet cosmonauts took an active part in perfecting methods for remote determination of the hydrophysical and biological characteristics of a water surface under the program of the international experiment "Black Sea-85," drawn up by scientists of the People's Republic of Bulgaria, German Democratic Republic, Polish People's Republic and the Soviet Union.

The Soviet Union is one of the participants in the international satellite system "COSPAS-SARSAT," intended for determining the position of ships and aircraft which have experienced accidents. Experience in its use confirmed the correctness of the technical decisions and the full compatibility of elements and parts of the system organized in different countries. The reliability of Soviet rescue satellites has been repeatedly demonstrated.

The range of terrestrial professions of Soviet space technology is becoming increasingly broader. This is made clear by exhibits in the pavilion of the main national exhibition. They also convincingly show that the USSR is exploiting space for the purposes of peace and progress. The position of the Soviet Union along these lines was set forth clearly in the Political Report of the CPSU Central Committee to the 27th Party Congress and in the declaration of Comrade M. S. Gorbachev, General Secretary, CPSU Central Committee, dated 15 January 1986 in the proposal of the Soviet State that the agenda of the 40th session of the UN General Assembly include the problem "International Cooperation in the Peaceful Exploration of Space Under Conditions of Its Nonmilitarization."

The body of the "Vostok" spaceship rests on powerful supports at the entrance to the "Space" pavilion. A quarter-century ago for the first time it carried into circumterrestrial orbit a representative of mankind, a citizen of the USSR. The feat performed by Yu. A. Gagarin is now being continued in peaceful space orbits by a new generation of Soviet cosmonauts. Their research is advancing the socioeconomic progress of our country, the socialist cooperation countries and all countries and peoples who link their present and future to mutually advantageous cooperation and peaceful coexistence on the planet earth.

5303
CSO: 1866/124

UDC: 551.46.0:629.78

POSSIBILITIES OF USING ARTIFICIAL EARTH SATELLITE DATA FOR COMPUTING HEAT EXCHANGE BETWEEN THE OCEAN AND ATMOSPHERE IN NEWFOUNDLAND ENERGY-ACTIVE ZONE DURING WINTER

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 2 Aug 85) pp 32-41

[Article by D.G. Rzheplinskiy and N.N. Shvyrkov, All-Union Marine Fishing and Oceanography Scientific Research Institute, Moscow]

[Abstract] Maps of the dynamic topography of the ocean surface in the Newfoundland Energy-Active Zone (NEAZ) were plotted on the basis of three oceanographic surveys made during the winter of 1983-1984. During the first survey (24 December 1983-6 January 1984) the main flow of the Gulf Stream at 50° longitude was traced in the latitude zone from 38 to 43°N. The second survey (7-28 January 1984) revealed no significant changes in circulation and temperature distribution in the test range. Observations made during the third survey (6-18 February 1984) confirmed the presence of the main forms of circulation in the region. The test range was regionalized on the basis of types of vertical distribution of temperature and salinity for determining the limits of propagation of different water structures. Three types of vertical structures were defined: structure of slope waters, structure of transformation zone and vertical North Atlantic structure. (Figure 1 shows curves of the vertical distribution of temperature and salinity during the three surveys; Figure 2 shows the boundaries of waters of different vertical structures in the NEAZ in the winter of 1983-1984.) It was found that the intensity of the heat flows between the ocean and atmosphere in the NEAZ in winter is dependent largely on the position of the hydrological front separating the North Atlantic central water mass from the remaining water structures and on the specific meteorological synoptic situation. Despite year-to-year or survey-to-survey changes, there are only a few typical combinations of states of the ocean and atmosphere. Any analysis of heat exchange between the atmosphere and ocean in the NEAZ is difficult on the basis of shipboard data alone. Shipboard data must be processed simultaneously with satellite data. An evaluation

of meteorological conditions is possible using scanner photographic images from satellites in the visible range. Identification of the position of hydrological fronts in the NEAZ is possible using IR information received from "Meteor" satellites. A speedy analysis of energy exchange processes between the ocean and the atmosphere on the basis of satellite data alone is possible, but the accuracy will be lower than combined use of shipboard-satellite data.

Figures 5, references: 4 Russian.

5303/8309
CSO: 1866/5

UDC: 551.25+553.042:528.77+629.78

EVALUATING CORRELATIONS BETWEEN STRUCTURAL ELEMENTS DETECTED FROM SPACE PHOTOGRAPHS AND METALLOGENETIC ZONES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 12 Nov 85) pp 42-50

[Article by M.A. Artamonov, V.M. Moralev, D.G. Rikhter and O.G. Sheremet, "Aerogeologiya" Geological Production Association, Moscow; Lithosphere Institute, USSR Academy of Sciences, Moscow]

[Abstract] Quantitative correlations were found between a broad spectrum of elements of structural lines characterizing the pattern on space photographs and geological features and the role of the subjective factor in the geological interpretation of the results was evaluated. The geological features used for this purpose were metallogenetic zones in Northeastern Transbaykalia shown on a metallogenetic map of the USSR at 1:2,500,000. These zones were compared with a space geology map of linear and annular structures of the USSR at 1:5,000,000 and a map of similar elements detected in this region on the basis of the results of an interpretation of intermediate-resolution space photographs. The research method was based on the same principles as in earlier work (O.G. Sheremet, et al., ISSLED. ZEMLI IZ KOSMOS, No 4, pp 15-19, 1982; No 5, pp 12-19, 1982) and involved use of cluster and correlation analysis, as well as a "uniformity coefficient," for six different mineralization zones. It was found that four of these six zones have high internal correlations with their mean characteristics (have high indices of the uniformity coefficients). The most informative criteria were determined. For sulfide mineralization, for example, they are the mean length of nonintersected linear structures and the degree or gradient of change in directions of E-SE linear structures, whereas for copper mineralization (associated with polymetallic or rare metal deposits) such a criterion is the number of arcuate and annular structures.

Figures 4, references: 5 Russian.

5303/8309
CSO: 1866/5

UDC: 528.77:550.814+629.78:550.3:551.24

COMBINING OF SPACE GEOLOGICAL AND GEOPHYSICAL METHODS IN REGIONAL AND LOCAL PREDICTION OF TECTONIC STRUCTURES IN CASPIAN DEPRESSION

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 20 May 85) pp 51-60

[Article by V.Ya. Vorobyev, Lower Volga Geology and Geophysics Scientific Research Institute, Saratov]

[Abstract] In the Caspian depression there is a shortage of areas which have been adequately studied for the initiation of exploratory drilling. This is attributable to the fact that seismic prospecting methods have inadequate resolution due to complex seismogeological conditions. Other geological and geophysical methods, in combination with remote methods, must be used in predicting structural inhomogeneities of the sedimentary cover. The combined method is discussed in this article in relation to regional and local prediction of platform structures. With respect to interpretation based on the optical density of space photographs, experience has shown that it is indispensable to carry out corresponding research using surface geological and geophysical methods for predicting structural inhomogeneities. On space photographs it is possible to interpret deep structure by an analysis of the interrelationship between lineaments of different strikes and optical density of images, on the one hand, and geological and geophysical parameters, on the other. Such studies were made using space photographs taken in the spectral zone 590-710 nm at a scale of 1:1,000,000 and photographs from "Meteor" satellites. A data file was organized which included borehole stratigraphic information, geomorphological and geophysical indices. The territory of the Caspian depression and its margins was broken down into 1,875 squares, each with a side measuring 20 km, within which a whole series of indices was determined, such as optical density gradations, strikes of faults and lineaments, structural elements of sedimentary cover, strike of local structures, prospects for detecting petroleum and gas, depth of basement and its dissection, spatial coordinates, hydrocarbon deposits, valleys by depth and direction, gravity anomalies, magnetic anomalies and salt domes. Traditional processing methods were combined with a quantitative structural analysis of images on an electronic computer. In space photograph interpretation emphasis

was on search for fundamental interpretation criteria and comprehensive indices indicating uplifted crustal blocks. Maps of density of lineaments were interpreted with the same objective. Computer processing of photoimages made it possible to plot optical density maps (illustrated as Fig. 1) and lineament maps (Fig. 2). These and similar investigations have been highly useful in planning a strategy for petroleum and gas exploration work for pinpointing sectors of subsalt deposits with depths accessible for modern drilling methods. A table is presented which reveals that many space geological and geophysical indices in their distribution provide information on the geometry of structural surfaces and residual optical density anomalies correlate well with the depth of subsalt horizons.

Figures 5, references: 7 Russian.

5303/8309
CSO: 1866/5

UDC: 626.8:631.6:582.71

IDENTIFICATION OF RECLAIMED LANDSCAPES IN BELORUSSIA FROM SPACE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 3 Jul 85) pp 61-67

[Article by V.I. Mikyalov, V.N. Gubin and A.A. Makarevich, Belorussian Polytechnic Institute, Minsk; Belorussian Geological Prospecting Scientific Research Institute, Minsk; Central Scientific Research Institute for Comprehensive Use of Water Resources, Minsk]

[Abstract] In Belorussia plans call for increasing the area of drained lands to 3-3.2 million hectares and the area of irrigated lands to 0.3-0.4 million hectares by the year 2000. However, too little is known about environmental conditions in Belorussia to ensure proper planning of an undertaking on such a scale. Already the negative consequences of proceeding with reclamation without proper knowledge of the environment are quite evident: overdrainage or overmoistening of the soil, sinking of peat bogs and deflation of sands due to dropping of the ground water level, development of erosional relief forms and activation of other exogenous geological processes. Remote sensing methods must be used for collecting objective information on natural conditions and the development of anthropogenic processes. Interpretation work was carried out with "Landsat" and "Cosmos" photographs at the original scale of 1:1,000,000 and with enlarged prints. The most informative photographs were taken in spring in the red (0.6-0.7 μm) and near-IR (0.7-1.0 μm) spectral zones. Special studies were made of neotectonics, soil-hydrogeological conditions and exogenous geological processes. The text fully discusses the results of these three types of studies (Figures 1-3 are the maps of features interpreted in these three studies). These materials illustrate the broad possibilities and practical importance of the landscape identification method for the interpretation of reclaimed lands in Belorussia and in planning further work.

Figures 3, references: 7 Russian.

5303/8309
CSO: 1866/5

UDC: 528.711(202):550.3:553.078(575.1)

USE OF SPACE PHOTOGRAPHS AND GEOPHYSICAL DATA IN PREDICTIVE METALLOGENETIC RESEARCH IN CENTRAL KYZYL KUM

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86
(manuscript received 4 Jan 85) pp 68-74

[Article by G.V. Galperov, V.E. Bogatyrev and A.V. Pertsov, Aerial Methods Laboratory, "Aerogeologiya" Geological Production Association, Leningrad]

[Abstract] The Central Kyzyl Kum is part of the Turan plate where the thickness of the Mesozoic-Cenozoic cover is as great as 3 km. Surface outcrops of the Hercynian basement form the western spurs of the Southern Tien Shan. A study was made of the structural-tectonic characteristics of the region and on this basis the distribution of mineralization was examined. Specifically, a predictive evaluation of gold mineralization was made for the sediment-covered areas of the Central Kyzyl Kum. The study was made using four generalization levels (continental, first and second regional, and local). For example, the joint use of the results of interpretation of space photographs and geophysical materials for the continental level of generalization made it possible to compile a map of the block structure of the studied region. It was found that in the southeastern part of the Turan plate the most promising areas are crustal blocks with a reduced thickness of the granite layer (10-12 km, where total crustal thickness is 40-42 km). Within these blocks the key features are large arcuate faults. The higher-order ore-controlling structures are annular structures with a diameter of 12-28 km, associated with arcuate faults and situated at the points of intersection of linear faults. The combined interpretation of space and radar photographs made it possible to study structural control of mineralization in poorly exposed and sediment-buried regions. The use of materials from the continental and first regional levels of generalization makes possible discrimination of the main structural units (blocks of different deep structure) and study of their metallogenetic specialization. Materials from the second regional generalization level make it possible to clarify the patterns of distribution of ore mineralization on a more detailed basis. Ore fields can be discerned by use of the local level of generalization.

Figures 4, references: 17 Russian.

5303/8309
CSO: 1866/5

UDC: 528.77:550.814+629.78(729.1)

LINEAMENTS IN EASTERN CUBA: EXPERIENCE IN GEOLOGICAL INTERPRETATION OF AERIAL AND SPACE IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 28 Nov 85) pp 75-85

[Article by V.I. Makarov, V.G. Trifonov, G.I. Volchkova, F. Formel, K. Brezhnyanskiy, J. Oro and K. Peres, Geology Institute, USSR Academy of Sciences, Moscow; Geology and Paleontology Institute, Cuban Academy of Sciences, Havana]

[Abstract] The geological research work initiated by Cuban and Soviet specialists in 1978-1979 under the "Intercosmos" program was later continued with emphasis on a number of regional tectonic problems, including study of deep structure of the territory, its neotectonics and recent crustal movements, the effectiveness of whose study by aerospace methods had already been demonstrated in different regions of the USSR. The data which have been obtained are important for understanding the structure of Cuba and the geodynamics of the Caribbean Basin as a whole. Such research in Cuba is equally important in predicting seismicity and in seismic regionalization, prediction of trends in changes in coastal zone configuration and relief, sutdy of surface deformations in internal regions of the island and search for structures with indications of mineralization. The article is centered on work of this type in southeastern Cuba, with emphasis on analysis of lineaments interpreted on black-and-white aerial photographs at 1:60,000 and multizonal space photographs from the "Salyut-6" and "Landsat" satellites. Interpretation was based on available geological material, including field observations. Figure 1 is a full-page map of lineaments and annular formations in the region studied; Figure 2 is an isoline map of the density of lineaments and geographical names. The pattern of these lineaments is discussed in detail in relation to other structures and formations. Much new information was obtained on the neotectonics and recent geodynamics of the region.

Figures 2, references: 5 Russian.

5303/8309
CSO: 1866/5

UDC: 528.8+519.272

STATISTICAL DESCRIPTION OF REMOTELY SENSED FEATURES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 14 Aug 85) pp 95-104

[Article by B.M. Balter and V.V. Yegorov, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] Any significant improvement in remote sensing methods requires use of correct models of terrestrial features and methods for their formalized description. In particular, the parameters of state of terrestrial features or their complexes (geosystems) must be subjected to a formalized description. This article gives an analysis of models describing the functions of "local" dependence of brightness and the state of a feature in an elementary cell. The principal parameters of such "cellular" random processes determining what methods of data analysis are applicable to them are examined and these methods are related to different types of statistical ensembles. Emphasis is on statistical description principles at the qualitative level without detailed mathematical analysis, which would be justifiable only after a more rigorous formulation of the problem. It is shown that application of statistical evaluation methods to remote sensing data must provide for choice of an adequate model ensemble and a model relating observations and the characteristics of a feature for which a priori information is available. The availability of such a model makes it possible to decide whether the mechanism of fluctuations of observations is constant from experiment to experiment with a stipulated accuracy. If not, it is necessary to broaden the model ensemble, taking into account the factors impairing this condition or to use an evaluation method of the Bayes type. This is in conformity to the general principle that the lesser the information present in observations, the greater must be the volume of a priori information in order to make a consistent evaluation. It can be stipulated in the form of a postulate of stationarity of the process, a Bayes a priori distribution or a specific model explaining the correlation in observations. Figures 3, references: 6 Russian.

5303/8309
CSO: 1866/5

UDC: 681.3:528.72

COLOR-TEXTURE SEGMENTATION OF AERIAL AND SPACE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 12 Jun 85) pp 105-112

[Article by R.I. Elman and Ye.I. Pamorozskiy, "Lesproyekt" All-Union Forest Surveying Aerial Photographic Association, Moscow]

[Abstract] In an earlier article (R.I. Elman, et al., ISSLED. ZEMLI IZ KOSMOSA, No 4, pp 110-119, 1984) a procedure was proposed for the segmentation of space scanner photographs by the two-step color selection method. However, a difficulty was involved: after the color selection of natural features the discriminated sectors are contaminated by many small inclusions resulting from color admixtures present in the texture of the sectors. The method has been improved by successive use of color and textural criteria of sectors, thereby eliminating this difficulty. A piecewise-uniform model was used in which it was assumed that the extent of the uniform sectors is at least an order of magnitude greater than the textural elements of these sectors, a property which is used for separate color and texture processing of the image, The following steps are involved: input and display screen synthesis of the color image; identification of all image elements (pixels) using color criteria, with a resultant porous image; separation of the pores using a textural criterion (area); smoothing-over of the pores by their coloring with the color of the adjacent field elements. Application of the method is illustrated in a computer experiment using a space photograph of the Vilyuy River region in Central Yakutia taken with the MKF-6 multizonal camera. The method was shown to be superior to methods used earlier.

Figures 3, references 9: 7 Russian, 2 Western.

5303/8309
CSO: 1866/5

UDC 535.361.2+57.084.2:535.243.3

PHOTOGRAPHIC METHOD FOR STUDYING SPECTRAL REFLECTANCE OF VEGETATION COVER

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 4, Jul-Aug 86 (manuscript received 18 Jun 85) pp 113-118

[Article by A.E. Kuusk, Astrophysics and Atmospheric Physics Institute, Estonian Academy of Sciences, Tartu]

[Abstract] A photographic method is proposed for studying the directional reflectance of the vegetation cover. A "Zenit" camera having an objective with a field of view 180° was used in registry of spectral reflectance from an An-2 aircraft and a Ka-26 helicopter. The image diameter was 20 mm and the projection was equidistant in the range of angles 0-80°. During photography the camera was hand held in such a way that the objective axis was directed to the nadir and horizontal position of the camera was checked with a level. The exposure could be increased to 1 s, during which the helicopter covered a distance of 20 m and the aircraft a distance of 40 m. The survey was made in June and August 1984 over the Estonian SSR. Directional reflectance of fields of agricultural crops and forested areas was determined. Figures 2 and 3 show, as examples, the directional reflectance of a birch forest and a barley field (cloudless weather, solar zenith distance 51°). The method has distinct advantages over direct photometric measurements. The airborne equipment is simple in design and easy to handle. Efficient use of flight time is very high. Photometric measurements of the negative in the laboratory makes it possible to select suitable diaphragms and nadir angle and azimuth intervals. The photographic method is highly desirable for the accumulation of initial information for checking models of reflection of radiation from the vegetation cover. On the other hand, the method has deficiencies. For example, there is a low metrological accuracy in registry of radiation flux intensities attributable to instability of the photographic process and during flight it is very difficult to position the brightness standard in the camera field of view. The photographic method is but a temporary solution which should be replaced by more sophisticated instrumentation.

Figures 6, references 6: 5 Russian, 1 Western.

5303/8309
CSO: 1866/5

UDC: 629.783

DETERMINATION OF COORDINATES WITH MULTIPLE-BEAM RADIO INTERFEROMETER BASED ON NAVIGATIONAL-GEODETIC SATELLITES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 3, May-Jun 86 (manuscript received 25 Mar 85) pp 466-468

[Article by N.A. Azbukina, V.A. Vasilyev, V.M. Zinenko, V.G. Peshekhonov]

[Abstract] A previous work by P.E. MacDoran presented a method for determining the coordinates of a point on the ground where the antenna of a multiple-beam radio interferometer is located utilizing four Navstar satellites without using signal codes. Four additional antennas are installed at reference points, the mutual position of which is determined by long-arm radio interferometric observation of quasars. The method requires sequential geodetic tie-in, allowing a maximum separation distance of the new point from the reference points of not over 200 km. This article presents a method for avoiding this limitation by the use of 5-6 reference points, fully defining the radius vectors of the four satellites during the course of the measurements. The four satellites must be separated by a distance of not over 30-35°. Five of the reference points must also be separated by a distance of about 30°, the sixth point may be up to two or three times closer. The position of the observer has little influence on the geometric factor. One condition of singularity is coplanarity of all satellites.

Figures 2, reference: 1 Western.

6508/8309
CSO: 1866/141

UDC: 581.526.42:629.78

EFFECTIVENESS OF UTILIZATION OF SPACE-DERIVED INFORMATION IN FORESTRY MANAGEMENT

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 1 Nov 85) pp 3-11

[Article by V.V. Yezhkov, A.P. Metalnikov, A.S. Isayev, V.I. Sukhikh, V.S. Kudryavtsev, and Ye.A. Shchetinskiy, USSR State Committee on Science and Technology, Moscow; Institute of Forestry and Timber imeni V.N. Sukachev, Krasnoyarsk; "Lesproyekt" All-Union Aerial Photography and Forest Management Association, Moscow; RSFSR Ministry of Forestry Management, Moscow]

[Abstract] Despite the fact that timber and forestry management has been practiced in the USSR since about 1950 and more than 10,000 personnel are now active in this work, only half of the forested area (675 million ha) has been studied to any extent. Forestry services process data on 47 million ha annually at a cost of about 50 million rubles. Since forestry information must be updated every 10 to 15 years, traditional techniques are inadequate. Similar problems of data volume and processing speed requirements also exist with present approaches to protection of forests and their exploitation. The use of aerial photography and remote sensing data from space platforms will make it possible to increase the time between updates of forestry management information to 20 years, which will cut in half labor and material costs for the estimation of forest reserves and their monitoring. If it is assumed that this time will apply to just 20 percent of the forested area being managed, this alone will reduce annual expenditures by 2 million rubles. If erosion protection plantings are improved and water utilization is thereby improved by 25 percent (which is feasible) then additional crop (grain) harvests will increase an average of 0.5 quintals per ha, totaling 80 million quintals for a protected area of 160 million ha. Space derived data is required for the implementation of such programs.

References: 21 Russian.

[127-8225]

/8309

UDC: 551.501.74:551.593.1

SOLUTION OF INVERSE REFRACTION PROBLEM IN CASE OF TRANSILLUMINATION OF EARTH'S ATMOSPHERE FROM SPACE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 19 Jul 85) pp 13-16

[Article by S.V. Sokolovskiy, USSR Academy of Sciences Institute of Atmospheric Physics, Moscow]

[Abstract] The use of radio and optical transillumination of the atmosphere for remote sensing of meteorological parameters encounters the problem of reducing the transillumination data, i.e., solving the inverse refraction problem. While an Abel inversion is usually employed for planetary atmospheres (assuming local spherical symmetry in the vicinity of the perigees of the transilluminating rays), in the case of the earth's atmosphere where more stringent requirements are placed on the precision of the results, it is necessary to use inversion techniques that take into account the horizontal inhomogeneity of the atmosphere. This paper analyzes a two-dimensional inverse problem of reconstructing the distribution of the index of refraction in the sensing plane. Data from the first global PIGAP (Program for Investigation of Global Atmospheric Processes) effort taken on 28 January 1979 are used in sample calculations in order to illustrate the accuracy of the proposed solution. The refractive inversion for three geographic areas (longitude 0°, latitude 25-65°' long. 90°, lat. 26-65°' long. 25-65°, lat. 0°) at barometric pressures of 1,500 and 250 mB. The numerical experiments demonstrate the feasibility of reducing the errors in refractometric transillumination by 50 percent with a fine enough sensing grid. The question of the choice of the number and configuration of the satellites is not treated here.

Table 1, figures 3, references 4: 3 Russian, 1 Western.

[127-8225]

/8309

UDC: 551.4:528.77+629.77

APPLICATION OF SPACE IMAGING TO STUDY OF MODERN LANDSCAPE DEVELOPMENT

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 21 Feb 85) pp 21-28

[Article by Ye.V. Glushko, Yu.G. Yermakov, and A.A. Serebrov, Pilot-Cosmonaut of the USSR, Department of Geography of Moscow State University imeni M.V. Lomonosov]

[Abstract] The Namib desert was photographed from the Gemeni-5 spacecraft on 27 August 1965. The color photographs with an original scale of 1:3,300,000 and a resolution of 80 m were used as the basis for a geological, geomorphological, soil, geobotanical and terrain interpretation of the region on a scale of 1:700,000 by means of comparison with similar photographs from later spaceflights. The subsequent terrain changes were noted in photographs taken from the Salyut-6 in September 1978 and the Salyut-7 on 23 August 1982; the latter photographs had a resolution of 70 m and a scale of 1:2,400,000 and were used to produce interpretive maps of the region with a scale of 1:1,000,000. This paper is a discussion of the evolutionary changes observed and provides a detailed 1:1,000,000 map of the map showing 17 different terrain features. Such space photography enables the tracing of the development of landscapes with great reliability and provides the greatest information on terrain evolution.

Figures 3, references: 4 Russian.

[127-8225]

/8309

UDC: 551.481:629.78

DETERMINATION OF REGIONAL FEATURES OF WESTERN SIBERIAN MARSHES FROM SPACE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 27 May 85) pp 29-37

[Article by S.M. Gorozhankina, Institute of Forestry and Timber imeni V.N. Sukachev, USSR Academy of Sciences Siberian Department, Krasnoyarsk]

[Abstract] Photographs taken from the Cosmos satellites using multizonal cameras and having a scale of about 1:1,000,000 are used to ascertain the information content of interpreted images in the study of Western Siberian marshes. Black and white photos in spectral ranges of 510-600 and 700-850 micrometers, as well as spectral band images were stereoscopically interpreted and compared. The 500 to 600 micrometer spectrum provides the greatest information, since it shows greater optical contrast of dry valley and hydromorphic components of the terrain, while the black and white images are considerably inferior to their multizonal counterparts. Detailed maps show the morphogenetic types of marshes in the northern portion of the Western Siberian plain, illustrating approximately 39 types of landscape features. The different types of marshes have their origins in predominately local features of the physical and geographical environment and are not duplicated in landscapes having different climatic, lithological and geomorphological characteristics. The signatures of the horizontal terrain structures show that the regional nature of these marshes consists primarily not in the typological composition based on the attributes of the present vegetation, but rather in their morphogenetic specifics. A map also details the marsh types in the Ob to Irtysh river interfluve.

Figures 4, references: 10 Russian.

[127-8225]

/8309

UDC: 528.77:550.814+629.78(729.1)

EXPERIENCE WITH GEOLOGICAL INTERPRETATION OF AERIAL AND SPACE PHOTOGRAPHS IN TROPICS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 4 Dec 84) pp 38-43

[Article by V.G. Trifonov, I. Alfonso and C. Peres, USSR Academy of Sciences Geological Institute, Moscow; Institute of Geology and Paleontology, Cuban Academy of Sciences, Havana]

[Abstract] The western part of Cuba, the province of Pinar del Rio and a portion of the province of Havana were geologically mapped from the interpretation of multizonal space photographs with scales of 1:400,000, 1:600,000 and 1:1,000,000 with terrain resolutions of 50 to 100 m. Black and white aerial photographs with a scale of 1:60,000 were also interpreted using additional data from field studies in key areas. A structural geological map of an area of 80 x 190 km centered approximately on Pinar del Rio is shown; it differentiates eight kinds of terrain features. The natural conditions in Cuba do not deprive space photographs of their geological information content, and sometimes even underscore the contrasts between structural and stratigraphic systems (tropic karst on limestone and increased laterite weathering crust on ultrabasic rock). Space photographs are particularly useful in the study of post-meseocene orogenic deformations imposed on a mantle-fold structure. The hydrothermal sulfide deposits of the region are linked to ring formations and fractures in the second stage of deformations interpreted in the photos. The latter two features can serve as predictive criteria for such deposits.

Figures 4, references 8: 5 Russian, 1 Polish, 2 Spanish.

[127-8225]

/8309

UDC: 553.4:528.77:550.814+629.78(571.55)

AERIAL AND SPACE PHOTOGRAPHY: BASIS FOR INTERPRETATION OF GEOLOGICAL DATA (USING EXAMPLE OF BALEY ORE REGION)

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 8 Jan 85) pp 44-48

[Article by O.N. Kolodiy, Yu.F. Misnik (deceased), V.V. Shevchuk, Lvov State University imeni I.V. Franko]

[Abstract] The Baley ore-bearing region of the Eastern Transbaikal exhibits ring and radial lineaments in aerial and space photographs. Such structures are associated with known ore fields and clusters, the best studied of which is the Aliinskaya structure with a diameter up to 20 km. A correlation of the interpreted structures with mineral, petrochemical and geochemical data reveals a subalkaline volcanogenic magmatic system with a concentric configuration exhibiting a ring structure of the various geochemical fields. The radial and ring system of fractures established from photographic interpretation made it possible to determine that the same types of ore clusters occurred along arcs having the same radius. High temperature mineral associations are replaced by lower temperature ones from the center of the structure to the periphery and a relationship is observed between the ore content and the areas with the greatest number of fractures. The hydrothermal mineralization of the Baley region can be clearly predicted from these correlations of temperature, pressure and chemical signatures with photographed structures. Detailed maps show the distribution of the mineralization, geophysical and geochemical anomalies as well as the temperature gradients of the mineral formations in the Aliinskaya central-type structure. The centrifugal nature of the minerological and thermobaric zonal structures indicates the position of major ore channels.

Figures 3, references: 6 Russian.

[127-8225]

/8309

UDC: 550.34+551.24:629.78

APPLICATION OF SPACE PHOTOGRAPHS TO STUDY OF SEISMICITY

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 15 May 85) pp 50-53

[Article by V.P. Loziyev, and M.S. Saidov, "Priroda" State Scientific Research and Production Center]

[Abstract] The structural relief related to the presence of fold deformations and fractures in rock masses is clearly seen in space photographs with various degrees of generalization. Transverse and diagonal faults are the most visible, generally as lineaments. This paper analyzes the association between such lineaments and areas of tectonic fracture clustering that intersect regions of seismogenic faults, using the Tien-Shan region (from around Fayzabad to Garm in the Karategino-Alayskiy sector) as an example. The geographical coincidence of Pleistocene earthquake zones and clustered fault systems indicates that the latter are due to tectonic fracturing produced at the points of greatest stress in seismogenic fault areas. The clear-cut structure of valleys and the coincidence of local bridging structures with tectonic fracturing clusters is evidence in turn that the cumulative erosion activity of rivers also clearly responds to the distribution of tectonic stresses in the earth's crust. The agreement between regions of thicker earthquake epicenters, tectonic fracturing and the greatest development of landslides is also clearly seen in photographs from space.

Figures 2, references: 11 Russian.

[127-8225]

/8309

UDC: 624.19:528.77:550.814+628.78

UTILIZATION OF SPACE INFORMATION IN PROVIDING PROTECTION AGAINST WATER IN MOUNTAIN TUNNELS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 6 Feb 85) pp 54-59

[Article by A.L. Revzon, O.V. Kutsnashvili, A.G. Gromov, and V.A. Krivenkov, All-Union Scientific Research Institute for Transportation Construction, Moscow; "Kavgiprotrans" Caucasus State Planning and Research Institute, Tbilisi]

[Abstract] Water hazards when driving tunnels in mountain rock are greatest in regions of tectonic fracturing along faults in the earth's crust. Experience with the construction of tunnels in such regions in the USSR and abroad has shown that ground surveys do not completely depict the true nature of the engineering geodynamic and hydrogeological situation along projected tunnel routes. This paper uses space imaging data to evaluate the engineering role of crustal faults in the development of practical plans to protect against water hazards. Field survey data from mountainous regions in the Caucasus are used the comparison example illustrating the supplementary nature of space information. A procedure is spelled out for evaluating the danger of faults to tunnels as well as a method for comparing space-derived data with vertical sounding, magnetic profiling and well-logging data. Interpretation of space photographs significantly improves the efficiency of ground surveys, enabling the determination of the location, number and size of areas requiring water hazard protection when driving tunnels.

Figure 1, table 1, references 6: 5 Russian, 1 Western in Russian translation.

[127-8225]

/8309

UDC: 528.7:629.78

SOLVING PROBLEM OF SPECTRUM RECONSTRUCTION WHEN USING MULTIZONAL SURVEY SYSTEMS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received after revision 3 Jul 85) pp 67-70

[Article by V.V. Bacherikov, V.V. Menshikov, O.A. Minayeva, V.I. Sapritskiy, and B.S. Elkin, All-Union Scientific Research Institute for Optical and Physical Measurements, Moscow; Kharkov State University imeni A.M. Gorkiy]

[Abstract] Narrow band filters are used at the signal inputs to multizonal spectrometers for remote sensing of the Earth from space. The radiation spectrum of the target must then be reconstructed from the measurement data for the various channels of the spectrometer. This paper uses a piecewise-quadratic function for the approximation of the unknown spectral response function; there is a discontinuity both in the function and the first derivative at the boundary between the media of the quadratic functions. In order to achieve a specified precision, one must solve a linear system with a substantially reduced number of unknowns. Analytical expressions are derived for the determination of the optimal set of filters for spectrum reconstruction with a specified accuracy. A sample calculation plots the spectral response function between 1,000 and 1,900 nm, characterizing the transmittance of the atmosphere over a horizontal path and also plots the reconstructed functions when 9, 10 and 18 filters are used. The values of the integrals of the reconstructed functions agree with the values of the original integrals in the first two cases with a disparity observed only in the fifth significant figure. In the 18-filter case, the computational error is less than the measurement error. This technique can also select the optimal filters from the approximate form of the emission spectrum and reconstruct the spectrum for filters with various responses.

Figures 2, references 4: 3 Russian, 1 Western in Russian translation.

[127-8225]

/8309

UDC: 535.243.1:632.2

REMOTE SPECTROMETRIC METHODS OF EVALUATING STATE OF WINTER RYE AFTER WINTERING OVER

Moscow ISSLEDOVANIYE ZEMLI IZ ROSMOSA in Russian No 3, May-Jun 86 (manuscript received 6 Aug 85) pp 71-76

[Article by S.F. Buga, Ye.A. Yanovskaya, A.F. Yanovskiy and L.A. Ushkevich, Institute of Physics of Belorussian SSR Academy of Sciences, Minsk; Belorussian Scientific Research Institute for Protection of Vegetation, Priluki Settlement, Minsk Rayon]

[Abstract] The state of winter rye in the spring can be assessed from aerial measurements of the light reflected from the fields. Reference values of the spectral brightness and spectral energy brightness density were determined in ground field studies of 23 winter rye plantings with various degrees of winter kill using an MSS-2K spectrometer with a spectral resolution of 0.007 micrometers between 0.5 and 0.9 micrometers. These field studies found that the spectral brightness coefficient falls off in the near infrared (0.73 to 0.90 micrometers) spectrum and this factor increases in the visible spectrum (0.50 to 0.68 micrometers) with an increase in winter-kill due to snow mold. The contrast between the spectral brightness of the soil and that due to dead winter rye vegetation is taken into account in deriving empirical formulas for the crop status evaluation. The second phase of the study used an MSS-2K spectrometer and "Nadir" polarization radiometer in an aircraft flown at 200 m over the fields at 150 km/hr; a spectral recording time of about 10 s covered an area of 25 by 300 m. Spectral brightness measurements of nine fields with winter rye in different states reveal a correlation between crop status and the red to near-IR reflectance ratio, with the healthiest crops being observed at high values of this ratio. The polarization also assists in arriving at a final assessment.

Figures 2, references 14: 11 Russian, 3 Western.

[127-8225]

/8309

UDC: 528.711.1(202):(528.714+551.521)

SPECTRAL BAND ILLUMINATION OF TERRAIN SURFACE IN REMOTE SENSING FROM SPACE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 7 May 85) pp 77-80

[Article by L.M. Matiyasevich, "Priroda" State Scientific Research and Production Center]

[Abstract] The illumination energy delivered to the Earth's surface in various spectral bands must be known in order to make accurate exposure calculations for aerospace photography and photometric measurements. The available data on the spectral composition of sunlight is used here to calculate a coefficient called the spectral band equivalent (on analogy with the light equivalent): $K = E_b/E$, where E_b is the spectral band illumination due to the total solar radiation and E is the integral illumination of the sun. Nine spectral bands (from 500 - 670 to 770 - 860 nm) are defined and used in the calculation of the individual spectral band illumination of the surface under cloudless conditions as a function of the angle of the sun. The values obtained correspond to the average normal transparency of the atmosphere and can be used for calculating the illumination energy at the surface in other bands. However, the method is applicable only to level terrain.

Figure 1, references 11: 10 Russian, 1 Western.

[127-8225]

/8309

UDC: 551.521.14:631.174.26

STUDY OF REFLECTANCE PARAMETERS OF FIELDS OF WINTER WHEAT IN VARIOUS STATES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 26 Jun 85) pp 81-89

[Article by A.D. Dobrozrakov, Yu.M. Kondratyev, Ye.B. Pospelova, and S.G. Yakovlev, State Scientific Research Center for Study of Natural Resources, Moscow; Moscow State University imeni M.V. Lomonosov]

[Abstract] Four test areas spaced 36 to 84 km apart in the north central portion of the Khersonskaya Oblast were singled out for remote sensing studies of the condition of winter wheat fields. Fields were graded as good, satisfactory and poor, based on a comprehensive characteristic reflecting the potential crop yield. This characteristic was determined from aerial observations using an "Aist" diffraction spectroradiometer and a digital recording magnetometer installed in a KA-26 helicopter flying at 80 km/hr at an altitude of 100 m. The radiometer objective covered an area of 65 m^2. The group variations in the spectral energy brightness density of the winter wheat fields is determined at wavelengths of 550, 670, 800 and 1,050 nm in order to establish the correlation between the spectral parameters and the good, satisfactory and poor ratings. The data taken during 22-25 May 1981 show that during the formation of the wheat head, the average values of the spectral energy brightness in the red and near-IR spectra differ significantly for the three ratings. The scale of variations related to the condition of the wheat considerably exceeds the differences in the reflectance parameters of the fields in the four test areas. The spectral brightness in the near-IR during the maturing of the wheat shows close values for fields in different conditions. Wheat field status in the late spring and summer can be determined through sensing data derived during head formation with a radiometric resolution of no worse $1 \cdot 10^{-7}$ $W/cm^2 \cdot sr \cdot nm$ in the red portion and no worse than 0.7 to $1.5 \cdot 10^{-6}$ $W/cm^2.sr.nm$ in the near IR portion of the spectrum.

Tables 5, figures 3, references 10: 7 Russian, 3 Western.

[127-8225]

/8309

UDC: 631.4:629.78

SPECTRAL REFLECTANCE OF SOILS AS FUNCTION OF THEIR SURFACE MOISTURE CONTENT

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 22 Feb 85) pp 90-93

[Article by S.M. Somova and P.P. Fedchenko, All-Union Scientific Research Institute for Agricultural Meteorology, Obninsk]

[Abstract] Samples of sod-podzolic soil were sifted through 0.5 and 1.0 mm mesh sieves into a test cell. An SF-18 spectrophotometer recorded the reflectance as a function of the wavelength (400 to 800 nm) before and after the addition of a water and water and glycerine mixture to the point of total capillary saturation of the soil. Soil reflectance in the case of a high water content is practically the same over the entire visible spectrum, while that of glycerine and water-glycerine saturated soil is a function of the wavelength. This paper is a detailed study of water containing soils that determines the spectral brightness as a function of moisture content and the angle of the sun using field survey data. A monotonic increase in the spectral brightness is observed with an increase in wavelength for both moist and dry soils as well as such soil-vegetative cover systems with air-dried and moist soils. The brightness falls off in the near-infrared and increases in the red portion of the spectrum in the case of a soil and vegetation system with a decrease in the vegetative cover. While several factors affect the spectral brightness of such systems, fields of grain can be assumed to exhibit a brightness that is a function of only two factors: moisture of the soil and the altitude of the sun.

Table 1, figures 3, references: 8 Russian.

[127-8225]

/8309

UDC: (551.573+57.084.2):551.2:629.78

POSSIBILITIES OF USING INFRARED BAND DATA FOR EVALUATING EVAPOTRANSPIRATION OF AGRICULTURAL CROPS

Moscow ISSLEDOVANIYE ZELMI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 5 Apr 85) pp 94-99

[Article by A.A. Feoktistov, All-Union Scientific Research Center "AIUS-agroresursy," Moscow]

[Abstract] The evapotranspiration flux density is one of the most important quantities determining the status of agricultural crops and can be found from the IR thermal signature. The remote sensing data in this case must be reduced by means of a differential approach, since the shortwave radiation albedo and the surface temperature used in the calculations are represented in difference form, and consequently the computed data will be less sensitive to errors arising with such remote sensing techniques. This approach additionally allows for the incorporation of apriori data from field studies in the computational scheme. Two approaches to the solution of the crop canopy energy balance equation are also discussed.

References 16: 2 Russian, 14 Western.

[127-8225]

/8309

UDC: 528.72(202):621.397.6

DATABASE OF CHECKING AND EDITING SYSTEM FOR DIGITAL TERRAIN DATA

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received 27 Mar 85) pp 100-106

[Article by I.S. Zabadayev, P.A. Kalantayev, V.P Pyatkin and V.G. Chubukov, Computer Center, USSR Academy of Sciences, Siberian Department, Novosibirsk]

[Abstract] An editing database has been written in MACRO-11 in the RAFOS operating system for the SM-4 computer for the checking and editing of digital terrain data on an interactive color display. The database is fully updatable and check and edits both metric and semantic data. It is similar to the Spatial Data Management System (SDMS) in that it works with objects assigned to rectangular image fragments (tiles). This paper details the database structures in the main memory and the performance as compared to the SDMS and MILES systems. The first stage of the database software has been developed and can process 2,000 to 3,000 digital terrain data points (data capacity is 0.7 to 1 Mbyte) where the execution time for individual editing operations does not exceed 7 s. An autonomous module is allocated for the generation of object images in the database. While an SDMS tile contains a compact raster representation of image fragment data not related to the information on specific objects, a T-fragment (analog of SDMS tile) in this system contains references to objects, thus imparting flexibility and speed to the editing. This database also can order the entries of individual digital terrain data objects into groups (lacking in the MILES system), thus facilitating the editing function when working with objects having the same semantic information structure; the structure of the R-descriptors of the MILES system is also less efficient in the implementation of the "dynamic window" than the substructure of the reference tables of T-fragments in this Soviet database.

Figures 3, references 14: 3 Russian, 10 Western, 1 Western in Russian translation.

[127-8225]

/8309

UDC: 551.510.534

METHODS OF ADJOINT EQUATION THEORY FOR PLANNING CONVENTIONAL AND SATELLITE METEOROLOGICAL OBSERVATION SYSTEMS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 3, May-Jun 86 (manuscript received after revision 6 Jul 85) pp 107-116

[Article by O.M. Pokrovskiy, Main Geophysical Observatory imeni A.I. Voyeykov, Leningrad]

[Abstract] The large network of space-based, ground and marine systems for observing the ocean-atmosphere system generates large volumes of data both continuously and intermittently. Optimization of the observational efficiency of the overall system requires the optimal integration of the conventional synoptic and new discrete observation data. Optimal synthesis of such data is based on the calculation of a satellite data value function that optimizes the remote thermal sensing of the atmosphere. The method of "adjoint equations" is applied to the analysis of the sensitivity of the hydrothermodynamic equations to the precision of the discrete and continuous data inputs. Sample calculations and maps show the location of satellite observation orbit segments corresponding to maximum values of the data value function for a variety of predictive models. The hydrodynamic model used is far from ideal and, therefore, the results of this simulation are to be treated only as procedural illustrations of the proposed approach.

Figures 4, references 13: 9 Russian, 2 Western, 2 Western in Russian translation.

[127-8225]

/8309

UDC: (550.814.528.77):553.98.003.1(575.1)

ECONOMIC EVALUATION OF USE OF MATERIALS FROM SPACE SURVEY OF EARTH IN COMPREHENSIVE INVENTORY OF NATURAL RESOURCES

Tashkent UZBEKSKIY GEOLOGICHESKIY ZHURNAL in Russian No 2, Mar-Apr 86 (manuscript received 26 Jul 85) pp 78-79

[Article by D.A. Tashkhodzhayev, A.A. Abduazizov, T.T. Tadzhiyev, N.E. Burkhanova and S.I. Ilkhamov, Geology and Petroleum and Gas Deposits Exploration Institute, Geology Ministry, Uzbek Academy of Sciences]

[Abstract] Virtually nothing has been published on technical and economic evaluations of the use of space sensing methods in studies of the Earth's natural resources. An attempt has therefore been made at determining the anticipated savings from the use of space survey materials in comprehensive mapping of natural resources in the Uzbek SSR. The expenditures on development, production and operation of space systems are compared with corresponding expenditures on nonspace systems performing these same functions. The assumption is made that space systems will always be more efficient because they carry instrumentation for solution of several problems simultaneously. It is further assumed that a survey from an orbital station or satellite gives technical data which cannot be obtained using aerial and surface methods; it enables studies of natural resources to be made better and more reliably; a space survey reduces the amount of field work by a factor of 2.5, but the amount of office work increases. In 5 minutes of surveying with an MKF-6 camera as much information can be collected as in two years of work by a specially equipped aircraft. With these factors taken into account, computations were made of the costs on compilation of a set of specialized maps of the territory of Uzbekistan in the example of a specific map sheet. Costs of map compilation work were determined using norms issued by the Main Administration of Geodesy and Cartography for editing, compilation and finalization work. Fifteen specialists participated in the test. Salary, overtime, fringe benefits, fieldwork costs and numerous other types of expanse were taken into account. The costs of producing the same work by traditional and space methods were compared and the great potential savings from use of space methods were evident.

References: 5 Russian.

5303/8309
CSO: 1866/134

UDC: 553.277:550.814

EXPERIMENT IN PREDICTING NEW POTENTIAL ORE-BEARING TERRITORIES USING SPACE PHOTOGRAPHS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOLOGICHESKAYA in Russian
No 7, Jul 86 (manuscript received 25 Dec 84) pp 94-105

[Article by G.M. Meytuv and A.A. Pugovkin, Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements Institute, Moscow]

[Abstract] An effort is made to clarify a number of problems in the geological interpretation of space information. Should space information be discarded if there is no geological explanation for the images obtained? In predicting mineral deposits is it possible to use images alone, without comparison with surface geological data? Can space photographs be used directly in clarifying the possible spatial patterns of distribution of mineral resources and in their prediction? Can new information be obtained by a statistical analysis of space data? An effort is made to clarify the spatial probabilistic-statistical relationships between known deposits and annular and linear structures. These relationships are used in defining standard geometrical images of ore-bearing areas which can then be used in the "direct" prediction of new ore regions, fields and deposits. The investigated area was an extensive territory in the southern part of Eastern Siberia. The initial data used were from an intermediate-resolution space photographic survey and small-scale photographs from the "Meteor" artificial earth satellite. Interpretation was accomplished simultaneously by several specialists who knew nothing in advance concerning the mineral deposit, thereby precluding personal bias. After a thorough discussion of annular structures and their relationship to mineralization and the relationship between linear structures and the occurrence of mineralization in their neighborhood, the usefulness of these relationships for predictive purposes is explored. It is shown that in many cases the prediction of mineralization can be accomplished directly on the basis of space data by making use of "ore-annular structures" and "ore-lineaments" spatial relationships. This is not meant to replace the geostructural approach. It constitutes an integral part of a predictive-metallogenetic analysis. The proposed method should be taken into account in planning and implementing predictive-metallogenetic research in new regions for which detailed geological and geophysical information is not yet available.

Figures 4, references: 8 Russian.

5303/8309
CSO: 1866/136

UDC: 528.77:550.34(575)

STRUCTURAL POSITION OF FOCAL ZONES OF EARTHQUAKES IN CENTRAL ASIA DETERMINED FROM SPACE PHOTOGRAPHS

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 6, Jun 86 (manuscript received 27 Mar 85 [as printed]) pp 134-138

[Article by M.Kh. Khadzhibekov, A.A. Abduazizov, V.N. Poltavchenko, D.A. Tashkhodzhayev, E.P. Gordeyeva and V.S. Yudin, Geology and Geophysics Institute, Siberian Department, USSR Academy of Sciences, Novosibirsk; "Priroda" State Center for Preservation of Natural Resources]

[Abstract] In the territory of Central Asia there are two major geostructural regions: the epiplatform orogenic region of the Tien Shan and the young platform of the Turan plate; these differ from one another with respect to geological history of development and intensity of recent tectonic movements. In this extensive area an effort was made to define seismogenic structures of regional importance and to evaluate their seismic activity, to establish the extent and approximate location of focal zones with different intensities of tremors and to evaluate the possibilities of using space photographs for seismotectonic regionalization. Use was made of materials from interpretation of space photographs obtained from the "Salyut" orbital station, with emphasis on the structural position of epicenters and earthquake intensity, together with qualitatively new data on earlier detected fault and plicative structural forms. This made it possible to plot a predictive map of possible earthquake zones in Central Asia, reproduced in the text, serving as a basis for the textual description of regional tectonics and seismology. It becomes clear that the epicentral zones of large and catastrophic earthquakes in the Tien Shan and the eastern part of the Turan plate tend to occur near the points of intersection of sublatitudinal deep and regional faults with meridional and diagonal lineaments. The structural diagram makes it possible to detect the zones of most probable occurrence of earthquakes. It is evident that remote sensing data make it possible to obtain information important in solving many problems in earthquake prediction. Seismic-generating structures gravitate toward zones of marginal deep faults. Seismogenic zones of a predominantly sublatitudinal strike coincide with the boundaries of the most recent uplifts and downwarpings and occur in zones of marginal faults.

Figure 1, references: 10 Russian.

5303/8309
CSO: 1866/135

UDC: 531.38

METHOD OF INTERPOLATING SATELLITE OBSERVATION ANGLES

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 24 No 1, Jan-Feb 86 (manuscript received 27 Dec 83) pp 138-139

[Article by V.V. Lavrov]

[Abstract] Satellite navigation requires precise knowledge of the direction of the line of sight to the satellite in a geocentric coordinate system. The direction of this sighting line is determined by two spherical angles that are computed by determining the mutual position of the satellite and the observation point. The position of the satellite is computed from its orbital elements, and in order to fix the signal, a large number of values of these spherical angles may be needed (on the order of several hundred), thus requiring considerable computer time. This brief paper outlines a method of interpolating the aspect angles as a function of time based on a few values. Satisfactory precision is achieved with the use of eighth order polynomials for the approximation. The start of the time readout is chosen in the center of the observation interval, and in order to preclude possible overflows when calculating polynomials of a high order and avoid small values of the coefficients, the time is normalized within the observation range into four segments. This produces a standard length interval with boundaries of $\pm$ 2.2. The proposed algorithm has proved to have sufficient accuracy and speed with a small amount of stored data.

Table 1, references: 1 Russian.

[101-8225]

/8309

MEETING ON BRITISH PARTICIPATION IN 'PROJECT ROENTGEN'

Moscow KOMMUNIST in Russian 3 Oct 86 p 3

[Text] A meeting with a delegation of the British National Space Center took place at the USSR Academy of Sciences' Institute of Space Research on 1 October. The delegation was headed by Roy Gibson, general director of the space center. The two countries' scientists discussed prospects for cooperation in the peaceful exploration of space. A memorandum was signed in line with the meeting's results.

"This meeting demonstrated that prospects for cooperation in space between Soviet and British scientists are good, particularly in such directions as astrophysics, radio astronomy, and space materials science," emphasized academician R. Sagdeyev, director of the space research institute. "A project called 'Roentgen' (X-ray) will become the first major joint project of our institute and the British National Space Center. The Netherlands and the Federal Republic of Germany will also take part in this project. An X-ray telescope developed with the participation of scientists of Birmingham University will be installed on a spacecraft. Plans call for placing it into orbit in 1987. I think that experience amassed in the course of this joint work will help us coordinate our future efforts. Space is in many ways a unique laboratory for scientists, and it certainly ought to be a peaceful one."

"We are pleased with the results of the meetings and talks with our Soviet colleagues," noted R. Gibson. "Directions of cooperation that are of mutual interest have been defined as a result. Mankind has much to gain from space, and it must be explored by joint efforts, of course."

The delegation of British scientists was received by academician V. Kotelnikov, vice-president of the USSR Academy of Sciences and chairman of the "Intercosmos" council, and A. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research.

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

SOVIET-FRENCH MEETING ON SPACE COOPERATION OPENS IN YEREVAN

Tashkent PRAVDA VOSTOKA in Russian 23 Oct 86 p 3

[Excerpt] (21 October, Yerevan)--The traditional annual Soviet-French conference on questions of cooperation in the study and use of outer space opened today in the capital of Armenia. This meeting marks the 20th anniversary of cooperation in this field between scientists and specialists of the two countries.

"Joint work is now proceeding in four main directions," noted academician V. Kotelnikov, chairman of the "Intercosmos" council. "They are cosmic physics, space medicine, and biology, space meteorology and aeronomy, and space communications. The USSR Academy of Sciences' "Intercosmos" council and France's National Center for Space Research are responsible for organizing the carrying-out of Soviet-French projects. In characterizing our cooperation, one should note its dynamic nature. Whereas specialists were discussing only five joint projects in the field of cosmic physics in 1967, more than 25 joint programs in this field were under consideration by 1979. We have advanced to a higher level of cooperation from such simple measures as exchanging information, joint formulation of experiments, and installation on Soviet spacecraft of individual scientific instruments produced in France. Now joint efforts include development of whole complexes of scientific instrumentation and also a number of service systems for spacecraft, plus organization of joint ground facilities for support of space experiments.

"As is known, agreement has been reached regarding a second and longer mission of a Soviet-French crew, on board the new orbiting station 'Mir.' I think that many new joint experiments for the study of sources of gamma and X-radiation in the universe, of Mars and its moon Phobos, and of the physics of sun-Earth ties are in prospect for us by the end of the present decade," said academician V. Kotelnikov in conclusion. "Medical personnel and biologists have made plans for a number of experiments. Meteorologists are working actively on studies of the upper atmosphere, and communications specialists are working on experimental telecasts between our countries, via satellites."

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

COMMENTARY ON SOVIET-FRENCH SPACE COOPERATION MEETING

Moscow IZVESTIYA in Russian 29 Oct 86 p 3

[Article by S. Bablumyan and B. Konovalov, correspondents (Yerevan)]

[Abstract] The article reports on the recent Soviet-French conference on cooperation in space research, which summed up 20 years of joint efforts by the two countries in this field and outlined future plans. Highlights of the latest success in this cooperation--the "Vega" international project to study Venus and Halley's Comet--are briefly described in the article, which contains quotes by two French scientists who took part in the project and who were honored at the conference.

It is also reported that the conference participants worked out more details of the plan for a flight by a French astronaut on board the Soviet orbiting station "Mir" in 1988. According to Prof. A. Grigoryev, deputy director of the Institute of Medical-Biological Problems, medical and biological experiments will occupy a central place in the program of this mission. He said that they will be a continuation of those experiments which were done during the flight of the first French astronaut, Jean-Loup Chretien. According to Yu. Semenov, director of projects for development of manned flight vehicles for international programs, it was decided that the French astronaut will work for 30 days on the "Mir" station. In addition to medical and biological experiments, he will do technological experiments, and it is planned that he will make a space walk together with a Soviet crew member. The French candidates for this mission are Chretien and Michel Tognini, and they are scheduled to arrive at Star City on 15 November to begin training. Semenov also mentioned that studies have begun in order to determine the possibility of docking the "Hermes" spacecraft, which France is developing within the framework of the program of the European Space Agency, with the "Mir" orbiting station.

At the closing session of the conference, Prof. J. Lyons, president of the National Space Research Center of France, and A. Dunayev, head of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research, signed a protocol concerning the upcoming joint manned mission, which will have the name "Aragats," after a mountain near the conference's host city of Yerevan.

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

ADDITIONAL COMMENT ON SOVIET-FRENCH MEETING

Moscow KOMMUNIST in Russian 29 Oct 86 p 2

[Excerpt] Fruitful cooperation between scientists and specialists of the USSR and France in the exploration and peaceful use of space is developing successfully for the benefit of the two countries and is serving the interests of progress. This was demonstrated by the presentations of participants of the Soviet-French space conference, which completed its work on 27 October in Yerevan.

The program of a new and longer space flight of a Soviet-French crew, which will take place during the second half of 1988, occupied a special place during the meeting of specialists from the two countries. Specifically, scientific studies of bone tissue, cardiovascular physiology and neurosensory function in humans, as well as experiments involving the deployment of spaceship structures during the French cosmonaut's extravehicular activity are planned during this flight.

The scientists defined problems of the preparation of joint experiments in all areas of cooperation. These include the projects "Granat," "Gamma-1," "Fobos," "Interbol," and "Biosputnik." Launch of the latter is planned for next year.

The Soviet and French specialists confirmed their interest in joint study of Mars and small bodies of the solar system and decided to continue work in this area. The sides also expressed interest in conducting experiments in the field of biotechnology for protein crystallization and electrophoresis.

In the area of space meteorology, the possibilities of conducting experiments on the radiation balance and on lidar probing of the atmosphere were examined.

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

SECOND CONGRESS OF SPACEFLIGHT PARTICIPANTS

Moscow IZVESTIYA in Russian 13 Oct 86 p 4

[Article by A. Ivakhnov (interviewer)]

[Excerpt] The second congress of the Association of Participants of Space Flights is opening in Budapest. USSR pilot-cosmonaut O.G. Makarov, a member of the Soviet delegation, told about the tasks of this congress.

"Soviet cosmonauts, U.S. astronauts and colleagues of ours from other countries formed the Association of Participants of Space Flights one year ago. This movement was initiated by 25 space researchers, who gathered in France in October of last year. Six representatives of our country and the same number from the United States were there, as were cosmonauts from socialist countries, our French colleague Jean-Loup Chretien, and an astronaut from Saudi Arabia. Many countries whose citizens have taken part in space flights sent delegates of their own.

"At that meeting, we decided to gather annually, so that we could move toward a set goal in a spirit of cooperation and mutual understanding. At the initiative of Hungarian cosmonaut Bertalan Farkas, the congress is being held in Budapest this time. Large delegations from the USSR and the United States as well as cosmonauts from socialist countries and a number of other countries are expected to attend.

"The motto of the congress can be translated differently into different languages, but its meaning is the same. Prospects for inhabiting outer space and creating near-Earth colonies will be discussed."

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

ANISIMOV AWARDED STATE PRIZE FOR WORK ON 'VEGA' PROJECT

Moscow LENINSKOYE ZNAMYA in Russian 24 Nov 86 p 4

[Text] The experiment with the "Vega" space project was followed closely by the whole world in the spring of this year. Unique pictures of Halley's Comet and new data on the planet Venus were obtained at that time.

As has already been reported, the high title of laureate of the 1986 USSR State Prize was conferred upon a group of scientists for development of the scientific complex of the "Vega" project. Among the award recipients was Doctor of Physical-Mathematical Sciences Sergey Ivanovich Anisimov, head of a sector of the USSR Academy of Sciences' Institute of Theoretical Physics imeni Landau.

(A photograph of Anisimov is given.)

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

STATE PRIZE NOMINATION FOR WORK ON PROCESSING OF ASTRONOMICAL IMAGES

Kiev PRAVDA UKRAINY in Russian 7 Oct 86 p 2

[Article by I. Zalyubovskiy, Doctor of Physical-Mathematical Sciences, Professor]

[Excerpt] A work-cycle entitled "Analog and Digital Processing of Astronomical Images" has been nominated for the Ukrainian SSR State Prize.

A substantial portion of this cycle is devoted to processing and analysis of results of space experiments. It consists primarily of radar maps of sections of the surface of the planet Venus which were compiled on the basis of data gathered by the American spacecraft "Pioneer-Venus," and a tremendous amount of work on filtration of cosmic noise in pictures of the planet Mars which were transmitted by the Soviet spacecraft "Mars-4" and "Mars-5."

The Presidium of the USSR Academy of Sciences approved an all-Union comprehensive program of ground patrol observations of planets of the solar system. Within the framework of this program, Kharkov astronomers have been making observations of planets. Impressive results have been obtained from observations of stars with the Soviet BTA six-meter telescope, the world's largest. The resolving power of this telescope has been increased by 100 times and its theoretical limit has been reached as a result of employing advanced methods.

The group whose work has been nominated developed a unique coherent-optical computer which has no counterparts from the standpoint of originality of technical solutions, and of precision and volume of calculations. For fast input of images into the computer, a high-speed microphotometer was developed whose parameters substantially surpass those of existing Soviet and foreign models. A digital image-processing complex was developed. Methods and algorithms were developed for solving a wide range of processing problems. Another very important fact is that the whole image-processing complex was developed solely on the basis of Soviet equipment.

FTD/SNAP
/8309
CSO: 1866/45

MEETING OF COSPAS-SARSAT MEMBERS

Moscow MOSKOVSKAYA PRAVDA in Russian 20 Nov 86 p 3

[Article by V. Khrustov, correspondent]

[Excerpt] More than 650 human lives have been saved with the aid of the international space system "COSPAS-SARSAT" for rescuing ships and airplanes in distress. At a working meeting of representatives of countries taking part in this international program, this figure was cited as an example of the high effectiveness of international cooperation in the peaceful use of outer space. This meeting took place in the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research on 19 November.

Scientists and specialists of Canada, the USSR, the United States and France discussed results of work and outlined long-range plans for further cooperation.

Yu. Zurabov, deputy chairman of the All-Union Marine Satellite Communications Association 'Morsvyazsputnik," told a TASS correspondent: "Our system is unique in many respects. Developed in a brief period of time, it made it possible to save several persons in distress even during its initial testing period, only two months after a Soviet satellite was launched. And now 100 to 150 citizens of various countries of the world are rescued each year with the aid of the system, even though it still has not become fully and permanently operational."

The latest meeting was a very productive one. Agreement was reached on creating a "COSPAS-SARSAT" office under the international marine satellite communications organization "Inmarsat." A corresponding intergovernmental agreement is now being prepared to establish reliable, long-term operation of the system.

"The 'COSPAS-SARSAT' system has demonstrated its reliability and effectiveness," noted D. Bailey, head of the American delegation.

The participants in the meeting visited the Cosmonaut Training Center imeni Gagarin.

FTD/SNAP
/8309
CSO: 1866/45

SPACE POLICY AND ADMINISTRATION

DEVELOPMENT OF SPACE LAUNCH ROCKETS RECALLED

Moscow KRASNAYA ZVEZDA in Russian 23 Sep 86 p 4

[Article by Ye. Bokhanov, test engineer]

[Abstract] The author recalls the development of the first space rockets under the direction of Sergey Pavlovich Korolev. He mentions that he worked with Korolev, and describes the working atmosphere in Korolev's design bureau. It is recalled that the first rocket developed by Korolev's bureau was the R-1, and it was launched 10 October 1948. The next rocket was the V-1A geophysical rocket, which was based on the R-1; it reached an altitude of 100 kilometers in May 1949. Subsequent rockets were the V-2A (2VA) and the V-5A (5VA). The first intercontinental ballistic rocket was tested on 21 August 1957. It was the R-7, and its so-called space version, "Sputnik," launched the first artificial earth satellite in October 1957.

The author goes on to discuss subsequent development of launch rockets for spacecraft, up to the "Proton" rocket, which was developed in the mid-1960's.

Four photographs are given showing the launch rockets "Sputnik," "Cosmos," "Soyuz" and "Proton."

FTD/SNAP
/8309
CSO: 1866/45

SPACE COOPERATION WITH INDIA, FRANCE REVIEWED

OW011351 Moscow Television Service in Russian 2340 GMT 28 Nov 86

[From "Man, Earth, Universe" program presented by Pilot-Cosmonaut V. I. Seveastyanov]

[Excerpts] [Sevastyanov] Soviet-Indian cooperation in space began soon after Gagarin's space mission. In 1962 Soviet specialists helped Indian colleagues to install equipment at the [word indistinct] launching pad. The first Indian satellite, Aryabhata, was built at the scientific center in Bangalore and placed in orbit with the aid of a Soviet rocket.

In 1972 the Soviet Union handed to India some of the lunar soil brought to earth by Soviet automatic craft for analysis. An Indian satellite tracking station was built with Soviet help in 1976. Gamma ray astronomy research began at approximately the same time. Soviet and Indian astronomers have been conducting joint study of star clusters and other projects. Soviet and Indian radiotelescopes were used during the joint Halley's Comet observation program.

In 1980 India launched the Rohini satellite with the aid of its own rocket and thus became the 7th state in the world capable of launching spacecraft with the aid of its own national facilities.

Joint work is being continued within the framework of the Soviet-Indian space cooperation program. The second natural resources study satellite, Bhaskara was launched from the Kapustin Yar Space Center. As in other launches" the Soviet Union provides the rocket and helps build some service systems for the craft.

In 1984, after two years of training for a joint Soviet-Indian space mission, Soviet cosmonauts Yuriy Malyshev and Gennadiy Strekalov and Indian Republic citizen Rakesh Sharma went into orbit.

[Announcer] The standby cosmonauts trained as hard as their doubles in space. Whatever happened in space had been tested a hundred times on land by the space and the standby crews. The most elaborate technological experiment--recrystallization--involved heating a sample alloy produced by an Indian laboratory with hot plasma produced by an electron gun. The sample then quickly cooled below the hardening point in the interplanetary frost

outside the station. The new glass-like structure made the metal superstrong and capable of being used in nuclear reactors, under bombardment from superpowerful doses of radiation.

Visibility was excellent all over India on 8 April. During the "Terra" experiment, the cosmonauts made about 2,000 photos with the aid of special photo cameras which provided very useful information. They may make it possible to uncover the mystery of the origin of the Himalaya Mountains and the great desert bearing the dismal name of Thar, which, according to ancient legends, broke off from the Caucasus Mountains and the Volga region. And they may make it possible to control the destructive sudden and terrible floods which kill thousands in India every year. They may make it possible to discover natural resources which cannot be located by land surveys. India badly needs to have its own oil and gas.

[Sevastyanov] The capsule in which the Soviet-Indian crew came back to earth was presented to India. At the presentation ceremony Indian Prime Minister Rajiv Gandhi said that the long Soviet-Indian cooperation in space had already borne rich fruit and the prospects for the development of this cooperation were very great and promising.

Our country is cooperating with many states in the peaceful exploration of space. Soviet-Syrian crews are now undergoing training in Star City. A decision has been adopted about conducting a second Soviet-Bulgarian mission. A long space mission with a representative of France is being planned. Jean-Loup Chretien and Michel Tognini arrived in Moscow on 15 November. They will train for the space mission.

[Begin recording] [Sevastyanov, addressing the two French astronauts] Jean, this year we observed the 20th anniversary of USSR-France cooperation in space exploration. You know that [words indistinct] Intercosmos exchanged ceremonial medals in Yerevan. What is your evaluation of the 20 years of cooperation between our countries?

[Chretien in Russian] It is very interesting to note that 20 years is a long time, and yet is is not so long. And there will be many more years to come. What we have achieved in these 20 years is astonishing [words indistinct]. Straight after our...[changes thought] we had many engineers who jointly [words indistinct], then there were the satellites, then there was our space mission. Now we are talking about "Hermes," joint work in the orbital station. All that is astonishing. I do not think there are many examples like this on earth.

[Sevastyanov] Not that many. That is correct. I would like to join you and say that this is really a clear example of longstanding and deep cooperation between the USSR and France and beginning with projects like "Araks," "Arkad," "Sneg", studies on the ionosphere....

[Chretien interrupts] Vega.

[Sevastyanov] Yes, the Vega experiment, and now "Phobos," also a joint project. Your remarkable space mission has already entered history. It forms a large stone in the foundation of our cooperation. And now we have the coming program. Now I have another question. How do you view this prospect? Michel will join in.

[Tognini, in Russian] I am also very happy. Our qualifying test was very hard. It is very important for me to train for the space mission. I am very happy.

[Sevastyanov, to Chretien] So there is work, work and work ahead for us.

[Chretien] Yes. Now we shall have to work every day. We shall do it with pleasure. We are very happy. It was a dream and it has now become....

[Sevastyanov interrupts] A reality. That is well, Jean.

[Chretien] Several minutes ago I told them how I reacted a year ago when Mikhail Sergeyevich Gorbachev, during his Paris visit, told me--Do you want to fly higher? I almost fell over. It was very pleasant.

[Sevastyanov] That is wonderful. The plans are now in the process of realization. Well, there is a long period of preparation and complicated training, because the equipment is complicated and the plans for developing scientific programs are expanding on the basis of gained experience. I wish you success in your training.

[Chretien] Thank you.

[Sevastyanov] Well, I think that we shall talk again. Within the framework of our program we shall report about your training. I wish you success.

[Chretien] Thank you.

[Sevastyanov in English] You're welcome. [end recording]

[Sevastyanov] France was the first West European country to sign, in 1966, an intergovernmental agreement on cooperation in space with the Soviet Union. About 50 major joint projects have been carried out in the last 20 years. Three French satellites have been launched with the aid of Soviet rockets. In 1982 the Soviet-French manned space mission was conducted aboard the Salyut orbital station. This spring we completed the international "Vega" project. USSR and French specialists, in association with its other participants, achieved splendid results in the study of Venus and Halley's Comet.

[Sevastyanov interviews V. M. Balebanov, deputy director of the Space Research Institute of the USSR Academy of Sciences]

[Begin recording] [Sevastyanov] Vyacheslav Mikhaylovich, how would you characterize in general terms the international cooperation with (?NEFA) and other French scientific organizations? What are the characteristic traits

of this cooperation and what successes have been achieved in jointly conducted experiments?

[Balebanov] Remarkable from the scientific point of view were the experiments conducted at conjugate points whem plasma emissions from sources aboard rockets fired from Kerguelen Island were sent into the force line of the earth's magnetic field. They actively affected the ionosphere of the Earth, and we felt that effect at the Earth's magnetic field high tension point near Arkhangelsk.

[Sevastyanov interrupts] In the form of an aurora borealis.

[Balebanov] In the form of an aurora borealis as the emission of particles excited the upper layers of the atmosphere. That was an excellent experiment at the beginning of the seventies.

The "Arkad-3" experiment was a very beautiful and fine one. It began in 1981 and is still being continued jointly with French specialists. We are studying the interaction of the solar wind with the Earth's ionosphere and magnetosphere. Very interesting plasma effects have been studied during these experiments. I would say that the most outstanding result is the discovery and detection of gamma bursts. This is a very interesting phenomenon which characterizes explosive processes on distant stars.

[Balebanov] The point is not only that we have managed to discover these explosions through their echoes, the pulsing gamma emission, but that we have also managed to determine the location of these explosive sources with some degree of accuracy, the place in the universe they come from. Among other very interesting results we can be justly proud of the results in the study of the planet Venus conducted jointly with French scientists. The French specialists have made a great contribution to the study of Halley's Comet at the last stage of the multipurpose "Vega" project.

We are discussing projects for the nineties with French specialists. These include projects for the study of Mars, of small bodies in the solar system, and especially of asteriods.

[Sevastyanov] The 7-day program of Soviet-French experiments conducted by Soviet cosmonauts and Jean-Loup Chretien aboard the Salyut-7 orbital station in 1982 is considered by specialists to be among the most significant joint projects conducted during the entire history of Soviet-French cooperation in space.

Three main lines of study were selected: astrophysics, materials science, and medical-biological experiments.

[A. I. Grigoryev, doctor of medicine] The Soviet specialists and our French colleagues focused their attention on research fields like the cardiovascular system, the state of the muscular and skeletal systems, and the state of the sensory-motor systems in space flight conditions. In this connection joint methodologies were developed and equipment was built. Most of the equipment

for investigating these joint ideas in the conditions of space flight was manufactured in France. Four joint experiments were conducted during the first Soviet-French space mission--the echography experiment, the Poza experiment, the "bioblok" experiment and the Tsitoz experiment. Two of these experiments, echography and Poza, have made it possible to establish a range of new very important changes and get a better understanding of the mechanisms of these changes during the acute period of man's adaptation to conditions of weightlessness.

The program of medical investigations conducted during the second joint Soviet-French space mission was discussed recently. French colleagues have now developed qualitatively new equipment which makes it possible to evaluate more closely the activity of the heart and blood vessels. Well, these questions were already studied during the short-term space mission. It is important to determine how the activity of these systems changes during man's longer period in conditions of weightlessness. That is when the process of adaptation enters a stable stage. In addition to these experiments they will study the important field of biological rhythms. We shall study the special characteristics of cosmonauts' sleep during long missions. And there can be no doubt that joint studies, Soviet-French cooperation which is developing so fruitfully, will contribute to the deepening of our knowledge about human physiological reactions in space conditions.

/9274
CSO: 1866/36

SHEVCHENKO COMMENTARY ON VALUE OF MANNED LUNAR BASES

Moscow APN: ADVANCES OF SCIENCE AND TECHNOLOGY in English No 15, 5 Aug 86 pp 1-4

[Article by Vladislav Shevchenko, Ph. D. (Physical-Mathematical Sciences): "Exploring the Moon in the 21st Century"]

[Text] The Soviet Union has advanced a program internationally for phasing up joint efforts to explore space peacefully in the remaining years of this millennium. The proposal is to create the conditions for Moon utilization early in the 21st century and to make it a base for interplanetary flights.

That dream of father of space theory Konstantin Tsiolkovsky might be realized somewhere around the 50th anniversary of the first artificial space satellite launch. The first plans for an international laboratory on the Moon were made back in the Sixties. It seemed then that the onward march of space technology would lead humankind on from the first Moon experiments to a long-term base there. The International Astronautic Federation set up a special committee to review the matter.

However, the Seventies saw interest in the Moon taper off. This was mainly because the emphasis in manned spaceflights was on investigating Near-Earth Space and setting up space stations. But progress in that work makes it clear that we soon shall view "Near Space" as the area within the lunar orbit, including the Moon itself. Deep examination of the Moon and development of its resources is an important and vital talk of harnessing Moon resources feasible? Hasn't man more pressing matters?

Science history holds plenty of examples where the first steps (take electricity or atom research) seemed of purely academic interest and grew into the fuel-core of technology.

What Moon forecasts can be made on current knowledge?

It has long been considered that a long-term life-supporting station on the Moon would be good for science. The Moon has unique natural resources which hold the key to some enigmas in Earth history. This realization has significance for tracking mineral formation. All space can be explored from an entirely new angle on the Moon. The high degree of vacuum and low gravity

on the Moon enable unique experiments. Further investigation is needed of Moon substances as not all the questions have been answered by research on Earth of what spacecraft have procured. For instance, why does Moon iron not rust? Why do plants set into Moon ground grow more intensively than on Earth? Why are Moon rocks non-magnetized?

The Moon has virtually no atmosphere and therefore probably contains traces intact of incredibly distant events relating to the first 500 million years of the Solar System. In any case, some rock samples brought back to Earth are considered by certain experts to have such an age. Particles flowing in the plasma flow emanating from the Sun leave microscopic traces in the sandy upper layers of crushed Moon rock. These tracks in the ancient material may reveal priceless information on Sun activity for the past 3-4 billion years.

Analysis of Moon ground, as it lies, may reveal Earth rocks of very ancient origin. Such ancient rocks have not remained intact on the Earth itself. On the Moon they could have survived largely unchanged billions of years. But how could such rocks have turned up on the Moon? Quite recently Moon rocks were discovered on Earth that had flown there as meteors. So why not the other way round? When our planet was yet young and its atmosphere not so thick, meteorites and splinters of larger bodies fell on it much more often than today. Each fall was accompanied by a great explosion. The particles thrown up in the blast could have flown off at the second cosmic velocity into interplanetary space and ended up on the Moon after a long journey.

Certainly, organizing such research on the Moon is no easy thing. It cannot be done by probes or short expeditions. But a team of researchers on the Moon on a long-term basis and properly equipped could take this on.

What significance could a moon base have for practical space science in the foreseeable future? The experts pinpoint several areas in which the Moon and its resources could be used for high Near-Earth orbits for manned missions and automatic systems. One of the biggest tasks before humanity is fully harnessing solar energy. There have been suggestions as to setting up energy installations on high orbits capable of generating electricity or beaming sunlight to the Earth. This would give rise to an entirely new power outlook with new space technologies and new methods in agrotechnics. All the pointers are that without Moon resources and lunar industries such projects will hardly be possible.

The energy expenditure in boosting a cargo off the Moon's surface into a high Near-Earth orbit is 20-30 times less than for the Earth itself. For example, the coefficient of cargo to total mass of a reusable space system at launch from an Earth space centre is a mere 1.5 percent. Launched from the Moon that coefficient could hit 50 percent.

In the future, space stations will be set into high or polar orbits on long-term manned missions and hundreds of tons of materials will be needed to protect the craft from solar and space radiation. Blocks of Moon ground

might well serve as that protective shield. It is reckoned that using Moon ground to protect manned spacecraft is more expedient than to launch fully equipped modules from the Earth or to transport the necessary cargoes into space for subsequent assembly.

Of course, establishing the first human settlement on another cosmic body will require great economic expenditure. Perfection of space technology will mean cheaper output and this will put cost at the moment of project realization at no more than was spent on manned expeditions to the Moon. The economists say that even given maximum outlay, the cost of a lunar base will be much less than "Star Wars". And can we evaluate in finite terms the benefit for mankind that will emerge from such international cooperation?

/6662
CSO: 1852/3

LAUNCH TABLE

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
3 Oct 86	Cosmos-1783	20,045 km	613 km	5 hrs 58 min	65.8°
6 Oct 86	Cosmos-1784	305 km	203 km	89.3 min	64.8°
15 Oct 86	Cosmos-1785	39,300 km	608 km	11 hrs 48 min	62.8°
20 Oct 86	Molniya-3	38,988 km	645 km	11 hrs 43 min	62.9°
		(Communications satellite for long-distance telephone, telegraph and radio communications and broadcast of USSR Central TV programs to points in the "Orbita" network)			
22 Oct 86	Cosmos-1786	2,589 km	198 km	113.3 min	64.9°
22 Oct 86	Cosmos-1787	290 km	215 km	89.3 min	70°
25 Oct 86	Raduga	36,618 km	--	24 hrs 39 min	1.3°
		(Communications satellite for telephone, telegraph and radio communications and transmission of TV programs; near-stationary, circular orbit)			
27 Oct 86	Cosmos-1788	520 km	472 km	94.5 min	65.9°
31 Oct 86	Cosmos-1789	316 km	196 km	89.3 min	82.6°
4 Nov 86	Cosmos-1790	315 km	207 km	89.4 min	72.9°

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
13 Nov 86	Cosmos-1791	1,026 km	972 km	105 min	83°
13 Nov 86	Cosmos-1792	357 km	181 km	89.6 min	64.9°
16 Nov 86	Molniya-1	40,817 km	469 km	12 hrs 16 min	62.5°
		(Communications satellite for long-distance telephone, telegraph and radio communications and broadcast of USSR Central TV to points in the "Orbita" network)			
18 Nov 86	Gorizont	35,824 km	--	23 hrs 57 min	1.4°
		(Communications and TV broadcast satellite; near-stationary, circular orbit)			
20 Nov 86	Cosmos-1793	39,323 km	611 km	11 hrs 49 min	63°
21 Nov 86	Cosmos-1794--Cosmos-1801	1,504 km	1,436 km	115 min	74°
		(Eight satellites orbited by single launch vehicle)			
25 Nov 86	Cosmos-1802	1,038 km	985 km	105 min	83°
2 Dec 86	Cosmos-1803	1,527 km	1,502 km	116 min	82.6°
4 Dec 86	Cosmos-1804	448 km	210 km	90.8 min	70°
10 Dec 86	Cosmos-1805	675 km	649 km	97.8 min	82.5°
15 Dec 86	Cosmos-1806	39,307 km	612 km	11 hrs 48 min	63°
16 Dec 86	Cosmos-1807	370 km	177 km	89.6 min	67°
17 Dec 86	Cosmos-1808	1,033 km	995 km	105 min	83°
18 Dec 86	Cosmos-1809	980 km	960 km	104.2 min	83°
		(To develop equipment and methods for survey of Earth's ionosphere and study of radio wave propagation in the ionosphere)			
26 Dec 86	Molniya-1	39,075 km	484 km	11 hrs 41 min	63°
		(Communications satellite for long-distance telephone, telegraph and radio communications and broadcast of USSR Central TV to points in the "Orbita" network)			
26 Dec 86	Cosmos-1810	302 km	189 km	89.1 min	65°

CSO: 1866/44-P

END